A BIOLOGICAL AND PSYCHOLOGICAL INVESTIGATION OF THE BEHAVIOURAL AND NEURAL CORRELATES OF SOCIAL EXCLUSION AND COOPERATION

Thesis submitted in accordance with the requirements
of the University of Liverpool for the degree of
Doctor in Philosophy

By

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July 2010

ABSTRACT

Distinct behavioural patterns in response to exclusion have emerged and at the forefront appear to be its impact on four fundamental human needs: belonging, control, self-esteem, and meaningful existence. Evolutionary theorists hypothesize that the potential danger of exclusion, or isolation from the group, has led to the development of a response system that is designed to counteract and prevent social exclusion, as well as to maximize attempts towards re-inclusion. Various aspects of a model for social exclusion were tested here. The first two experiments investigated the impact of social exclusion on four fundamental needs as well as its impact on cognitive style and cognitive processing. Results showed that social exclusion negatively impacted belonging, control, and self-esteem and that cognitive style as well as cognitive performance were impacted by exclusion. A second pair of studies investigated the neural correlates associated with social exclusion and cooperation. The first examined how individuals' responses to social exclusion were impacted, not by level of exclusion, but by the source's (of exclusion) level of resemblance to one's self. Results indicated that specific areas of the brain associated with social pain were active in response to exclusion, and that activation was greater in response to exclusion from in-group members (individuals of the same race or self-resembling faces). Lastly, a hyperscanning fMRI study of cooperation was conducted. Findings suggested that when two people cooperated to complete a maze task, a particular area of the brain involved in reward, the caudate, was recruited. This suggests that compared to working alone, individuals found something inherently rewarding in cooperating with another human. The relevance of these findings is discussed, and they are incorporated into an existing model of social exclusion and ostracism.

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ACKNOWLEDGMENTS

The author wishes to express the most sincere appreciation to Dr. Steven Platek for his amazing and enduring enthusiasm in my ideas and these projects. It is for his help, direction, and support that I am most thankful. I would also like to thank Dr. Todd Shackelford, Dr. Robin Dunbar, and Dr. S. Craig Roberts for their guidance and assistance in the preparation of this manuscript. In addition, special thanks to Dr. John Lycett and Dr. Rebecca Elliott whose guidance and advice during my viva was immensely helpful in creating a better end product. Thanks also to the many participants and friends who volunteered their time to take part in these studies. This work could not have been carried out without assistance from The Pioneer Fund. Additionally, on a more personal note, I would like to thank my parents, James and Suzanne Krill, for their ongoing patience, support and pride in my achievements.

GLOSSARY

Social Exclusion: The experience of distress as a result of an actual or perceived psychological or physical distance from others.

Rejection: Rejection incorporates a distinct assertion that an individual is no longer wanted in the group.

Ostracism: The ignoring and exclusion of individuals or groups by individuals or groups.

Cooperation: Associations of persons for a common benefit.

Chapter 1 An Introduction to Social Exclusion and Cooperation

> *"If no one turned 'round when we entered, answered when we spoke, or minded what we did, but if every person we met "cut us dead" and acted as if we were non-existing things, a kind of rage and impotent despair would ere long well up inside us, from which the cruellest bodily tortures would be a relief; for these would make us feel that, however bad might be our plight, we had not sunk to such a depth as to be unworthy of attention at all."* -William James (1890/1950 p. 293-94).

1.1. Introduction

William James' words vividly capture the devastating feelings that suffering from exclusion can create within the human mind. His depiction extends so far as to describe the experience of ostracism as even more painful than the "cruellest bodily torture" in that he classifies the torture as a *relief* from the agony of ostracism. If exclusion causes the trauma that James describes, it is not surprising, then, that exclusion is often depicted in very dramatic and compelling terms: Williams (2007) described exclusion as "powerful and ubiquitous" and Ouwerkerk et al. (2005) identified it as the "social death penalty." Since exclusion exists on so many levels, and because of its pervasive nature, few among us have attained adulthood without experiencing some level of exclusion whether it occurs on the primary school playground, feeling like a third wheel in a

teenage/adolescent trio, or a purposeful shunning and ultimate severing of communication. Exclusion is universal and timeless, and it's a purposeful and potent tool (Kurzban and Leary, 2001; see also Sidanius & Pratto, 1999). Williams describes the following, "The pervasiveness of ostracism throughout a society, institutions and small groups is matched by the high frequency of interpersonal dyadic relationships. Indeed the prevalence of ostracism is such that most individuals will be both a target and a source of ostracism in their close relationships, whether with colleagues, loved ones or strangers" (2001, p. 9). In an issue of *Ethology and Sociobiology* dedicated to the investigation of ostracism, Gruter and Masters (1986) thematically illustrated that ostracism is often utilized as means by which individuals are identified as targets and they are excluded in an effort to "preserve the group's cohesiveness and survival" (Williams, 2001, p. 9; See also Gruter and Masters, 1986).

The investigation of social and exclusion and cooperation in this thesis was conducted through the application of evolutionary principles and theory. Evolutionary psychology and theory can help us to understand the ultimate mechanisms behind social exclusion, and how it is tied to and what purpose it might have served in our evolutionary history. In fact, my examination of social exclusion *presumes* that natural selection has shaped a series of adaptations in order to help species solve recurrent survival and reproductive (i.e. adaptive) problems during evolutionary history (Darwin, 1859; Williams, 1966). This perspective assumes that group co-habitation has been occurring for several million years, or has at least been a recurrent part of human evolutionary history, and thus the human psyche has undergone selection pressures which favoured adaptations to solve the recurrent problems associated with co-habitation among group members (Kurzban and Leary 2001; Caporael and Brewer, 1991; Cosmides and Tooby, 1989; Gigerenzer, 1997; Humphrey, 1976; Williams, 1966). Because affiliation and cooperation with individuals is likely to generate fitness benefits as well

as fitness costs, a system, a proximate evolutionary mechanism, to differentiate and detect defectors (as well as cooperators) is presumed to have evolved in the brain. As a counterpart to this system, those who face the threat of exclusion have mechanisms intact to cope with the threat of exclusion. Using the application of evolutionary psychological principles, this thesis examines the behavioural responses and neural correlates associated with exclusion and cooperation, specifically relating to those who are targeted for exclusion and the coordinated neural activity involved in a cooperative game. Additionally, while evolutionary psychology provides the majority of the theoretical framework for the research carried out in this thesis, I do draw from many disciplines within psychology throughout this manuscript. It is important to mention this, as some portions and information may seem disparate. Despite all of the existing theoretical approaches in psychology, I believe that all of these theories can be best characterized using evolutionary psychology as an overarching metatheory; "Because all behaviour owes its existence to underlying psychological mechanisms, the central task according to evolutionary psychology is to discover, describe, and explain the nature of those mechanisms" (Buss, 1995, p. 7). Given this, the application of evolutionary principles is essential to any thorough investigation of behaviour. Gruter and Masters (1986) are among the first to explain the merit of investigating social exclusion and ostracism from an evolutionary perspective, "First, the process by which some individuals are isolated or excluded from interaction with other members of a social group is observed in many other species as well as in virtually all known human societies. Hence it is plausible to hypothesize that human ostracism may have physiological substrates or biological functions in addition to cultural, moral, and legal dimensions. Second, ethological studies of animal behaviour have shown the complex interaction between cooperation, competition, and exclusion; particularly among non-human primates, phenomena like "scapegoating" and shunning seem to play an integral role

in the maintenance of social order" (Gruter and Masters, 1986, p. 150). A new perspective on social exclusion may be revealed by examining it through evolutionary lenses because of the relevance of social exclusion in human evolutionary history. This chapter will discuss the foundations of ostracism, social exclusion and rejection, followed by a discussion of evolutionary perspectives and group membership processes. In the latter portion of the chapter, relevant literature will be reviewed providing a background on the neural correlates of social exclusion and its relationship to anxiety and impact on four fundamental (human) needs. The chapter concludes with a description of William's model of ostracism and a description of the remaining chapters that make up this manuscript.

1.1.1. Ostracism, Social Exclusion, and Rejection

Humans are inherently social creatures who seek out and enjoy the company of others. This need for social relationships seems to have "deep roots" in our evolutionary history. The incidence of being intentionally separated from a group has many names such as ostracism, social exclusion, and rejection. Each of these terms relates to some kind of separation from a group or others, but they all have distinct definitions. Ostracism refers to the ignoring of individuals or groups by other individuals or groups (Williams, 2007). Social exclusion can be described as the experience of distress as a result of an actual or perceived psychological or physical distance from others (Eisenberger, Lieberman, and Williams, 2003; Twenge, 2000). Finally rejection incorporates a distinct assertion that an individual is no longer wanted in the group (Leary, 2005). Whilst there are a variety of terms and definitions used to describe these interpersonally aversive episodes, researchers tend to use the terms interchangeably as will be the case in this manuscript.

No matter the name, ostracism has been around for a very long time. Some of the first records of ostracism come from the Athenians in 500 BC

(*ostrakismos*). As mentioned previously, human beings of all origins and descents use exclusion, and it has even been observed in primitive tribes throughout the world (Bohem, 1986; Gruter and Masters, 1986; Williams, 2007; Zippelus, 1986). There is, however, a great deal of convincing evidence that ostracism and exclusion are not only observable among humans, but also among other social animals. Examining exclusion in other species allows for the bolstering of the argument that social exclusion is rooted in human evolutionary history. Kurzban and Leary state, "The continuity of evidence across species at least makes the argument plausible… that if these adaptations have occurred in other species that face adaptive problems that might have been similar to those faced by our hominid ancestors" (2001, p. 191). For example, there have been many instances of animal species such as non-human primates, lions, wolves, buffalos, and bees employing exclusion in their social groups (Gruter and Masters, 1986; Wilson, 1980). Territoriality is one way that non-human animals exemplify exclusion. This is a form of exclusion where animals exhibit behaviours that exclude conspecifics from certain areas to sequester resources or mates (Kurzban and Leary, 2001; Wilson, 1980). Status hierarchies are another mechanism for exclusion. Animals that are in the upper echelon of the hierarchy impose restrictions on and exclude lower ranking animals. These imposed limits exclude animals from access to certain food, mates, and preferential areas. Chimpanzees have also shown evidence of stigmatizing and excluding members of their group who are ill. Jane Goodall (1986) describes one polio-infected chimp, in particular, who was ostracized from his group because he exhibited abnormal behaviour. These examples are not evidence substantiating that humans exclude each other in the same ways or for the same reasons, yet it is likely that many non-human social animals have faced adaptive problems similar to those of our early (social) human ancestors, thus evolving to deal with these selective pressures by employing exclusionary tactics (Kurzban and Leary, 2001).

1.1.2. Evolutionary Perspectives: Evolution of Ostracism and Social Exclusion

From an evolutionary perspective there are many benefits to be gained from social group membership. For instance, group membership can include benefits such as protection, sharing of food and resources, sharing of information, defined social structure, bi-parental care and allo-parenting, and general social support. Moreover, Gruter and Masters (1986) suggest that there are benefits to a group if they employ ostracism as a tactic to weed out useless and draining members of the group. Ostracizing burdensome members allows the group to become more cohesive as well as reducing competition between members for reproductive opportunities and resources. Given this perspective, one might argue that recognising, using, and avoiding ostracism could be described as biologically significant and reflects selection for adaptive preferences or adaptations. In some instances, the evolutionary psychology (EP) approach utilizes the term adaptation differently from other approaches. Barrett, Dunbar and Lycett (2002) characterise EP's use as follows; "Evolutionary Psychology does not consider the demonstration of reproductive benefits necessary to determine whether or not a particular feature is an adaptation. Instead they look for evidence of 'good design' " (p. 13). Moreover, I am not comparing reproductive success rates to determine whether or not avoiding social exclusion is adaptive, but I will presume that since it appears to be a good design that it is adaptive. Kurzban and Leary (2001) outline three "suites of adaptations" that are related to stigmatizing and excluding individuals: dyadic cooperation, coalitional exploitation, and parasite avoidance. Allow me to preface this by saying that it is debated whether a series of separate, very specifically designed, systems or one or more general/overlapping systems is driving these adaptations; however it is not the purpose of this thesis to make that determination. Instead, I will assume that these

mechanisms have evolved and do in fact exist as proximate neural mechanisms that drive human behaviour. Adaptations relating to dyadic cooperation allow individuals to avoid involvement with poor/low quality partners, those who pose a social cost which exceeds the benefit, as well as those who do not measure up as social partners (Kurzban and Leary, 2001). Group members engage in coalitional exploitation by keeping members of other groups out and seizing the resources of non-group members. Lastly, parasite avoidance is another means of exclusion whereby individuals can detect possible parasite carriers (through appearance, facial symmetry, masculinity, etc. for a review see Thornhill and Gangestad, 1993) and avoid them by limiting exposure to them through exclusion. These adaptations work well and to the advantage of the excluder, and most likely, without these mechanisms social exchange, cooperation, and group living might not have evolved, as cheaters would have the full advantage, reciprocity would not be expected, and social exchange would not have been beneficial (Kurzban and Leary, 2001). Indeed, exclusion is effective because of the negative consequences that it poses for the target. Those who are not members of a group are faced with the burden of complete self-sufficiency, and self-sufficiency can be a dangerous status for individuals. Therefore, it is in one's best interest for survival to avoid exclusion from the group, which is why detecting ostracism could be considered adaptive and most likely co-evolved with the use of ostracism (Williams, 2007). Individuals who are good at detecting possible exclusion would be at an advantage, allowing them to effectively predict and avoid exclusion.

1.1.3. In- and Out- Group Membership and Processes

Group membership and group identification play an important role in social exclusion and cooperation. As mentioned previously, in coalitional exploitation, individuals will often exploit the resources of other groups and exclude members of that group from access to resources simply because of

group membership (Kurzban and Leary, 2001). This assessment of group interaction adopts an evolutionary perspective and suggests that individuals have an evolved adaptation in the brain that is specifically designed towards dealing with problems in a group environment and group cooperation and competition. However, there are many other perspectives regarding group membership and intergroup relations. For instance, Hogg and Abrams (1998) also suggest that group membership is important in the realm of social exclusion. They state the following: "Social categories and groups are clearly one type of target of exclusion, particularly if they are minorities, are unfamiliar, and pose any kind of threat. Social categories are also powerful agents of exclusion" (p. 17). This social psychology perspective is applicable throughout and is a good place to begin the discussion of in- and out- group effects.

Sherif (1966) defines the term intergroup behaviour as, "Whenever individuals belonging to one group interact collectively or individually, with another group or its members in terms of their group identification, we have instances of intergroup behaviour" (p. 12). Humans define themselves by their social group membership and as a result social interaction and behaviour are impacted (Hogg and Abrams, 1998). Group identification can be very strong thus leading people to act in certain ways according to their group membership.

Group impression and stereotype formation (Stallybrass, 1977) as well as ethnocentrism (Sumner, 1906; see also Tajfel, 1982) are terminology that social psychologists have coined to describe the processes that establish individuals' "ideas" concerning out-groups and in-groups (Tajfel, 1982). The main underlying theme in all of these theories and definitions is that individuals, in most cases, show an overwhelming preference for their in-groups' behaviours, beliefs, and practices. Brewer (1979) states, "Any categorization rule that provides a basis for classifying an individual as belonging to one social grouping as distinct from another can be sufficient to

produce differentiation of attitudes towards the two groups in the absence of any initial competitive interdependence" (p. 307). Tajfel and Turner (1986) developed the theory of social identity, which suggests that there is "a shift towards the perception of self as an interchangeable exemplar of some social category and away from the perception of self as a unique person" (Turner et al. 1987, p. 50). In other words, social identity theory is a "depersonalization shift from the self and "I" focused concept to a "we" group focused identity" (Brewer, 1991, p. 478). The aforementioned explains one possible way that cognitive representations for in-groups are developed. While understanding the formation of these cognitive representations is important, understanding the initial forces that may have been the catalyst for group formation is essential. Brewer suggests that group living is the primary survival strategy for human beings. This strategy was most likely selected for during a time of "environmental scarcity" and where forming groups led to an increased likelihood for survival. Additionally, over time humans have "abandoned" many of the natural defences that may have once existed which allowed for solitary or paired survival; thus humans are left with "cooperative interdependence" as their primary survival strategy (Brewer, 1999). According to the optimal distinctiveness model of social identity, "If social and intergroup boundaries are functional for social cooperation, there should be psychological mechanisms at the individual level that motivate and sustain group identification and differentiation" (Brewer, 1999, p. 434). Group membership can be determined by any number of characteristics including race and genetic relatedness. Race is often a cue that is used to make group membership determination, as is genetic relatedness. These cues for group membership and their significance will be discussed in depth in Chapter 5. Finally, two very important components of group membership and identity are inclusion and exclusion; individual and group differences are treated as a primary basis for inclusion and exclusion (Abrams et al., 2005). Individuals

often feel a need for inclusion, especially when they feel isolated or removed from the group; however, there is also a need for distinctiveness, which can be defined by group membership (Brewer, 1999). Furthermore, inclusion can be used to benefit group members, and exclusion can be used as a means to punish defecting group members or to protect resources from intragroup competitors (e.g. coalitional exploitation) (Kurzban and Leary, 2001).

1.2. Neural Correlates of Social Exclusion: The Social Pain Response System

Humans tend to seek out the company of others presumably because as a species natural selection put a premium on the ability to maintain group membership; as a result, proximate psychological (and neural) mechanisms have developed to effectively cope with the problems associated with sociality. It has been suggested that the intensity of the social distress response, when facing potential exclusion or abandonment, may come as a result of its overlap with physical pain matrix in the brain (specifically in the dorsal anterior cingulate cortex), and this link has an adaptive value (DeWall and Baumeister, 2006; Eisenberger, Jarcho, Lieberman, and Naliboff, 2006; MacDonald, Kingbury, and Shaw-Binns, 2005). The physical pain system may have "provided the foundation for some of the physiological mechanisms that regulate social behaviour" (MacDonald et al., 2005, p. 78). Pain sensation and pain affect combine to create the "feeling" of pain. Pain sensation is the actual physical response to pain by the nervous system, whereas pain affect is the emotional counterpart. Pain affect is responsible for creating a feeling of "adversiveness" in response to the injurious stimuli and motivating one to make necessary adjustments to "end exposure" (MacDonald et al., 2005; Metzack and Casey, 1968; Price, 1999). Darwin (1859) noted that many complex traits evolved from earlier traits that served a different function, and such may be the case with the

social pain system. MacDonald et al. claim that, "painful feelings came to be associated with the cues predictive of exclusion experiences because evolutionary pressures made the regulation of inclusionary status critical to survival" (2005, p.79). Therefore, the pre-existing pain mechanisms required for the prevention and detection of physical harm may have been adopted by the later developing social attachment system in an effort to avoid and detect separation. This is especially important for mammals, which have a long period of dependence on maternal resources and care. Since the need for close contact and proximity is important for mammalian infant survival, especially altricial species such as humans, experiencing "pain" in the event of separation would be an adaptive response that would help to prevent harmful consequences of the separation as well as to re-establish close proximity with a care taker (Panksepp, 1998; Panksepp, Herman, Conner, Bishop, and Scott, 1978). Once one reaches adulthood, the care of a mother is no longer necessary, and the protection and care of a group becomes the symbolic vestige of this attachment. Thus this system remains intact; however it is used to signal potential danger as a result of separation (i.e. exclusion) from the group, not from the mother. This adaptive distress response to separation is called social pain. Social pain has been defined as, "the distressing experience arising from the perception of actual or potential psychological distance from close others or a social group" (Eisenberger and Lieberman, 2004, p. 294). In other words, social exclusion and rejection have been found to engender feelings of distress or social pain, and this social pain response seems to share its neural correlates with the physical pain system in the brain.

In one examination of this possible systemic overlap, Panksepp (1998) reported that young mammals experiencing separation anxiety no longer made distress calls after opiate injections, often used to alleviate physical pain symptoms, were administered to them. He inferred that perhaps the social pain system is structured around the physical pain system,

specifically around substrates sensitive to opiate action. This finding has recently been partially replicated in humans. DeWall et al. (2010) showed that administration of Tylenol, acetaminophen, reduced the feeling of social pain in a standard social exclusion paradigm. Neuroimaging studies have presented evidence pointing to the dorsal anterior cingulate cortex (dACC) as a structure responsible for acting as the neural alarm system for social pain in humans (Eisenberger and Lieberman, 2004). Notably, the dACC is also associated with the "unpleasantness" response accompanying physical pain (Rainville et al., 1997). Bachevalier and Loveland (2006) reported that the ACC is instrumental in directing attention toward sensory stimuli and regulating components of exploratory behaviour. The dACC also holds the title of conflict monitor in the brain. This region is involved in response to incongruent information such as that presented in the Stroop Task. Regulation of affiliation has also been attributed to this structure. Lesions to the anterior cingulate cortex have produced a marked decrease in social interactions as well as in vocalizations between mother and infant (in squirrel monkeys), demonstrating a relationship between this structure and affiliative behaviour (Eisenberger et al., 2004). Eisenberger et al. (2003) conducted an fMRI study of social pain using social exclusion as a means to investigate the neural correlates of social pain in humans. Individuals participated in a virtual ball toss game, ostensibly with two other players, while they were in the fMRI scanner. Results revealed a positive correlation between increased activity in the dorsal anterior cingulate cortex (dACC) and self-reported distress when participants were excluded from the game, implicating that the dACC is directly connected to feelings of social pain or rejection. Researchers have set out to define the relationship between physical and social pain and the underlying computational mechanisms. Eisenberger and Lieberman (2005) argue that "Because the dACC is involved in the experience of both physical and social pain it is plausible that the underlying computational processes of

the dACC are relevant in the processing of both types of pain" (p.109). Eisenberger (2008) discusses that factors which cause or alleviate pain should have an effect on both physical and social pain. For instance, social support, which is known to alleviate social pain, is also instrumental in alleviating physical pain. Supplementary evidence to support the relationship between social and physical pain comes from one study in particular. MacDonald et al. (2005) suggest that highly sensitive individuals, prone to hurt feelings, have a higher sensitivity to pain. As emotional sensitivity increases so does physical pain sensitivity. In an additional experiment, they discovered that individuals with a proclivity towards hurt feelings demonstrated an increased distress response, including a decreased pain threshold following exclusion. This response to exclusion demonstrates that, to highly sensitive individuals, exclusion poses a very serious threat (MacDonald et al., 2005). One final link between social and physical pain indicated that pain is a mechanism through which "perceived rejection promotes increased caution and defensiveness" (MacDonald et al., 2005, p. 86). While I cannot begin to account for all of the research examining the overlap between social and physical pain, I have attempted to highlight a selection of significant findings here. The take home point is that it has been hypothesized that the human brain has developed a means, by piggy-backing on the physical pain system, to cope with exclusion in a way that signals to the individual (via social pain) that exclusion poses a danger and the situation needs to be reconciled to avoid this possible danger. In the next section I will discuss the emotional and fundamental components that comprise "social pain."

1.3. Anxiety and Fundamental Needs

The need to belong has been driven by evolutionary consequences of being excluded, which likely drove the evolution of proximate neural adaptations in the brain; thus it might be described as a fundamental motivation

(Baumeister and Leary, 1995). The need to belong fits the following criteria of a fundamental motivation: it stimulates goal directed behaviour to satisfy it, cognitive activity reflects a concern with the need, and emotional reactions accompany satisfaction or dissatisfaction. In this section I am going to focus on the emotional reactions that follow when relationships are threatened or devalued: anxiety and impact on four fundamental needs (Baumeister and Leary, 1995). Before I continue, I want to note that there are many definitions and uses of the term *anxiety* in psychology. As Baumeister and Tice (1990) describe, anxiety can pertain to a clinical diagnosis of anxiety (which needs to be treated with medication or therapy), phobia, fear, panic, stress, as well as negative affect. In this case, the use of the term *anxiety* pertains to the negative feelings (feelings of anxiousness) and affect that accompany the threat of exclusion. Furthermore, the issues accompanying the definition of anxiety are not important here for the same reasons that they were irrelevant to Baumeister and Tice's (1990) discussion, "The definitional problems associated with the term anxiety, therefore, do not concern us greatly here. The central argument is that human beings are prone to experience strong doses of negative affect, akin to fear and panic, in connection with the prospect of being excluded from important social groups" (p. 166). Throughout I will use the anxiety to describe the negative affect, or fear (possible panic) associated with the threat of social exclusion.

When social attachments are threatened there is a decrease in positive affect. For instance, individuals demonstrate a variety of negative affects after the loss of a relationship. Baumeister and Leary (1995) argue that, "People feel anxious at the prospect of losing important relationships, feel depressed or grief stricken when their connections with certain other people are severed, and feel lonely when they lack important relationships" (p. 506). In accordance with this, social exclusion (loss of belonging) has been targeted as one of, if not, the most common cause of anxiety

(Baumeister and Tice, 1990; Leary, 1990; Leary et al., 1995). Anxiety that occurs as the result of a fear of exclusion or separation could serve to help a person from being excluded from the group altogether, as it may motivate a response – a behavioural change – from the exclusion target. If one accepts that anxiety is a component of fear, then anxiety can be interpreted the same way as fearfulness; it serves to warn an individual that danger is, or may be, lurking close by and they must act quickly to change the situation or their behaviour in order to avoid danger (Baumeister and Tice, 1990). This scenario may typically be related to avoidance of fear producing stimuli such as snakes and spiders (Ohman and Minkea, 2001); however it can be applied to social situations (i.e. group membership), which are important to survival (Baumeister and Tice, 1990; Buss, 1990). Baumeister and Tice (1990) write, "If anxiety serves as an interrupt mechanism, the central benefit of anxiety prompts cognitive reassessment. Hence anxiety should have strong effects on attention, for it must take the mind out of its current task and focus, and somehow prompt it to re-evaluate the project from a different perspective" (p.170). According to exclusion theory, anxiety is the primary tenet that underlies the negative affect, which accompanies exclusion (Baumeister and Tice, 1990; Baumeister and Leary, 1995). Exclusion theory purports that when any social bond is threatened anxiety ensues. Furthermore, uncertainty about social bonds can also elicit anxiety (Baumeister and Tice, 1990). An additional component in exclusion theory accounts for the anxiety that surrounds the "fear" of death (Solomon, Greenberg, and Pyszczynski, 1991). Baumeister and Tice (1990) have incorporated some ideals from Becker's existentialist theory (1973). The connection between social exclusion and death can be clarified by returning to an evolutionary perspective. In evolutionary history, exclusion likely had dire consequences, and one of those consequences might have been death. Because of the close relationship between exclusion and death in humans'

past, the threat of exclusion and death remain linked. Exclusion theory suggests that because death and exclusion are linked and death is the ultimate exclusion, it is another source of anxiety relating to social exclusion (Baumeister and Tice, 1990). However, mentally healthy people do not constantly experience feelings of anxiety about death, nor do they ruminate about the possibility of exclusion from the rest of the world. Research suggests that the strong correlation between self-esteem and anxiety alleviate, or suppress this type of thinking (Leary, 1990). When individuals feel that that they are important and significant to the world (they have a meaningful existence) the anxiety surrounding death is diminished (Baumeister and Tice, 1990; Solomon et al., 1991).

1.3.1. Four Fundamental Needs

Given all of this, it seems that anxiety is at the root of social exclusion; yet there are other feelings that may be diminished along with the increase in anxiety. Williams (1997; 2007) argues that four fundamental needs are impacted by exclusion; belonging, control, self-esteem, and meaningful existence are jeopardized when an individual is targeted for exclusion. I have particular interest in this model as I have used it as the basis for my assessment of social exclusion. As mentioned previously the need to belong sits at the core of this model. When the need to belong is threatened by ostracism it leads to a feeling of dissatisfaction (Williams, 1997; Baumeister and Leary, 1995; Baumeister and Tice, 1990; Buss, 1990). Self-esteem is also threatened by exclusion. Assuming that one uses self-esteem as a measure of their importance to others (e.g. a group) and society (Greenberg et al., 1992; Greenwald, 1980; Steele, 1988; Tesser, 1988), self-esteem is thwarted when a person is excluded (Leary, Tambor, Terdal, and Downs, 1995). The third component of the model is control. Seligman (1975, 1998) contends that individuals need to feel control over their social environment (see also Friedland, Keinan, Regev, 1992; Taylor and Brown, 1988; Taylor

et al., 1992). There is a specific threat to control that comes from being ostracized; thus this social motive is impacted by social exclusion. Finally, meaningful existence can be threatened by exclusion. Williams et al., (2005) ascribe to the same theoretical perspective as Baumeister and Tice (1990). They claim that meaningful existence is a reminder of mortality (Solomon, et al., 1991) and a "very palpable metaphor for death" (p.23). When the threat of exclusion is present, it can prompt thought of death, as death has routinely been connected to social exclusion during human evolution. While other needs may be impacted by social exclusion, threat to these four basic needs is the cornerstone of social exclusion theory. Responses to the threats can be seen in the form of immediate upset, pain, and hurt feelings. Beyond the immediate feelings individuals generally tend to fortify these needs by making attempts at increasing the feeling of belonging, regaining control, as well as increasing feelings of self-esteem and meaningful existence.

1.4. Behavioural Responses to Social Exclusion

Responses to exclusion are most commonly those that would be beneficial in moving one toward reintegration into the group or "improving exclusionary status" (Williams, 2007, p. 439). It seems logical to presume that pro-social responses increase the likelihood that one will avoid exclusion. Studies have shown that this is the case. For instance, female participants responded to exclusion by exhibiting a pro-social response during a group collaborative task following exclusion. However, non-excluded females, and all males (regardless of inclusion or exclusion status), exhibited social loafing during the group task (Williams and Sommer, 1997). Furthermore, excluded participants, regardless of gender, agreed to an obviously incorrect assessment of a perceptual judgment task when a majority of a group also agreed, whereas included participants did not conform. Carter-Sowell and Williams (2005) report that compared to included participants, ostracized participants exhibited an increased

willingness to comply during foot-in-the-door (Freedman and Fraser, 1966; Burger, 1999) and door-in-the face techniques (Cialdini, Vincent, Lewis, Catalan, Wheeler, and Darby, 1975) which are tactics used to persuade targets to agree to a suggestion or grant permission for something (e.g. Foot-in-the-Door: "Would you be willing to read a chapter of my thesis?" Followed by, "Actually, would you mind reading the entire thesis?" Door-in-the-face: "Would you read my entire thesis by tomorrow? Followed by "Would you just read the first chapter?"). In addition to this, excluded individuals are willing to give an exaggerated positive rating to others based on criteria that does not merit such a rating (Wheaton, 2001). Aside from overt pro-social behaviour, unconscious behaviour changes seem to also occur after exclusion. Excluded individuals tend to mimic group members' behaviour, and mimicry has been shown to increase affiliative behaviour (Lakin and Chartrand, 2005). Ostracism evoked increased attention to social cues and tone of voice in an unconscious effort to improve social standing and regain inclusion (Gardner et al., 2000; Pickett and Gardener, 2005; Pickett et al., 2004). All of these responses seem to be adaptive. It would be very beneficial for a person to regain inclusion by employing prosociality, and it makes sense that these behaviours would have evolved in an effort to do so.

On the other hand, ostracized individuals have also been reported to demonstrate aggressive behaviour in the face of ostracism (Buckley, Winkle, and Leary, 2003; Leary, Twenge, and Quinlivan, 2006; Twenge, 2005; Twenge, Baumeister, Tice and Stucke, 2001) as well as to decrease prosocial behaviour towards excluders (Twenge, Baumeister, DeWall, Ciarocco, and Bartels, 2007) in a numbing response to social exclusion.

1.5. Social Exclusion and Cooperation

To this point, a majority of this chapter has focused on how individuals control their avoidance of exclusion and how they react when faced with

exclusion. However, now I want to shift focus and briefly discuss matters associated with the causes and evolution of social exclusion, which I touched upon briefly in Section 1.2., and relate this to cooperation. Functionally speaking, exclusion can be employed as a behavioural control mechanism, which works to motivate people to act in accordance with group norms and rules, ultimately benefitting the group or partnership (Gruter and Masters, 1986; Brewer, 2005; Ouwerkerk, Kerr, Gallucci, and Van Lange 2005; Kerr, 1999). Ouwerkerk et al. (2005) have demonstrated the utility of the threat of exclusion in generating and maintaining cooperation among group members. Kurzban and Leary (2001) argue that exclusion is useful to avoid inopportune cooperative partnerships, which has resulted in the development of restrictions. In turn, these restrictions allow cooperative interactions to be productive and provide punishment for violators. Therefore, cooperation is benefited by exclusion, and the target of exclusion benefits from cooperating. I have generated a figure to help explain the relationship between exclusion and cooperation (See Figure 1.1.). This figure describes my interpretation of the cyclical nature of the relationship. Allow me to emphasize that I am not referring to cooperation and inclusion synonymously. A person can be included and not be cooperating. However from a functional perspective, exclusion and cooperation require efforts from both parties and are not just a state of being (as is the case with inclusion) but functional behaviours that have a directed outcome. It is the function that both cooperation and exclusion serve that connects them.

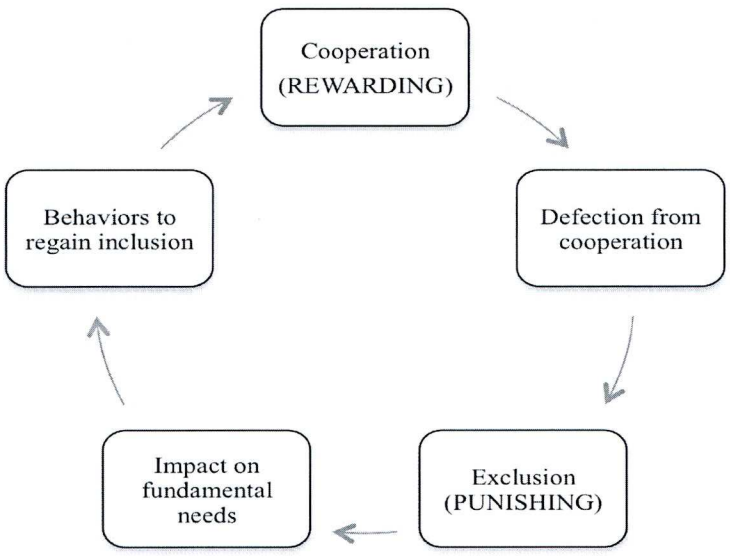


Figure 1.1. Hypothesized Relationship between Cooperation and Social Exclusion.

In summary, the threat that exclusion poses to the fundamental needs requires that humans have a system in place to allow for the observation and protection of their level of social inclusion, and they must be able to respond with the necessary coping strategies when threatened with exclusion (Ouwerkerk et al., 2005; Leary, et al., 1995; Pickett and Gardner, 2005). Possession of a system with such a purpose indicates that the threat of exclusion is very a powerful tool that can be used by groups to deter behaviours that are damaging to the group, or the ultimate goals of the group. Therefore, defection is deterred and cooperation is emphasized, and cooperation can be stimulated by the threat of exclusion (Kerr, 1999).

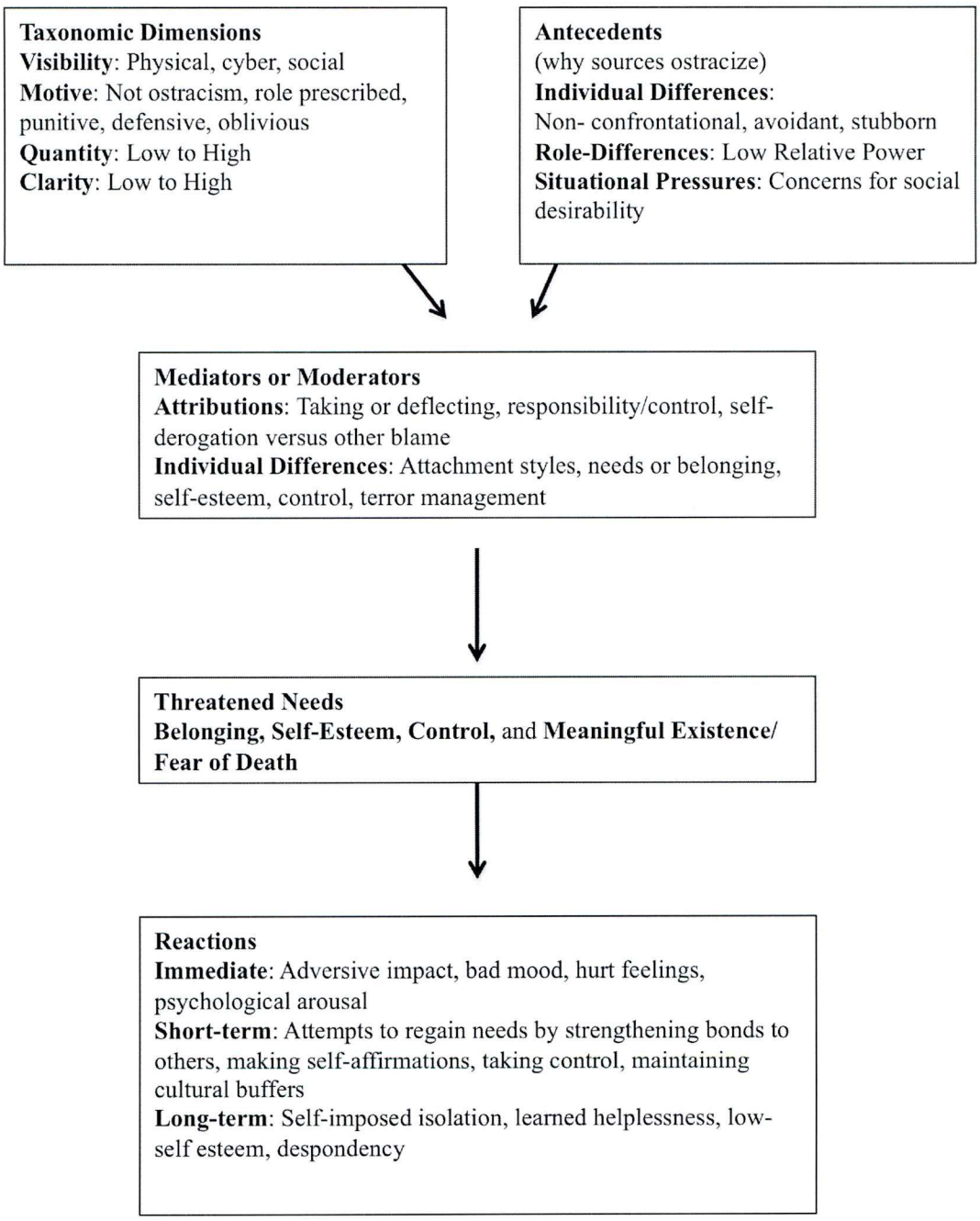


Figure 1.2. Williams' (1997) Model of Ostracism.

1.6. Introduction to theoretical model and incorporated experiments

Thus far the reader has been introduced to the following: (1) the more specific components of exclusion; (2) a foundation outlining the proposed links between exclusion and cooperation; (3) a discussion of the four

fundamental needs; and (4) the theoretical cornerstones supporting social exclusion research. Allow me now to introduce the model used as the scaffolding for the theoretical investigation of three of the experiments included in this thesis (see Figure 1.2.). Williams' Model of Ostracism (1997; 2007) describes the classification of the following: *Taxonomic Dimensions*, *Antecedents* of ostracism, *Moderators or Mediators* of ostracism, the *Four Needs Impacted by Ostracism*, and the *Reactions* to ostracism with consideration for a temporal element (immediate, short-term, long-term) (Williams, 2001). I found Williams' model (1997; 2007) useful for two reasons: 1) it helped to tie together ideas that alone may seem disparate, and 2) it was useful in guiding the experiments, because as each study progressed it helped clarify how my discoveries were related to each other and to the model. Williams (2001) describes the primary aim of the model as follows, "Even though all forms of ostracism contain the common elements of ignoring and excluding, my observations led me to believe that various forms of ostracism were likely to have different causes, serve different purposes, produce different consequences, and have different interpretations" (p. 47). The model can be read as a top to bottom model, however it is not predicated upon following that chronology. The first module is the *Taxonomic Dimensions*, and it classifies ostracism in four categories: *visibility*, *motive*, *quantity*, and *causal clarity*. These dimensions help to define the type of ostracism episode. *Visibility* category includes the following: physical ostracism, social ostracism, and cyberostracism. Williams (2001) explains, "Separating ostracism into three levels of visibility is important only insofar as the levels produce different effects on the targets" (p. 49). Cyberostracism is particularly important to this thesis, and the model suggests that when individuals feel that they are in the "communicative presence of others," cyber-ostracism can have the same effects as physical and social ostracism. The *motive* category recognises five motives for ostracism that targets may ascribe to ostracism episodes: not

ostracism, role-prescribed, defensive, punitive, and oblivious. The *quantity* of ostracism refers to the degree of ostracism. For example, one could be somewhat avoidant of the target or one could completely ignore and never speak to the target again. *Causal clarity* is the last category of the *Taxonomic Dimensions*, and it can vary between episodes. In instances of high causal clarity, the cause, or reason behind ostracism, is apparent. In instances of low causal clarity, there is ambiguity surrounding the motive for exclusion.

The second module of the model is *Antecedents*, which includes the following: characteristics of the source, characteristics of the target, and characteristics of the situation. This module is important in defining why a source uses ostracism, why a target may be the recipient of ostracism, and the situations that may predicate the use of ostracism.

Moderators and Mediators is the third module. This module includes the moderators and mediators of ostracism. Williams gives several examples of possible moderators: attributions of responsibility for the ostracism (external locus of control), personality of targets, and variation in attachment styles. These moderators (and mediators) are important because they can have an impact on the ostracism episode and how the target responds to ostracism.

Following the *Moderators and Mediators* module is the *Four Fundamental Needs* module. This module is the crux of Williams' model. He suggests that ostracism and exclusion uniquely impact four fundamental needs: belonging, control, self-esteem, and meaningful existence. The *Reactions to Ostracism* module lists three temporal stages: immediate, short-term, and long-term. It appears that time is an important component in a target's response to ostracism. In the immediate temporal stage, the four fundamental needs will be impacted. The short-term responses to ostracism may include attempts to reconnect with the sources or attempts to reinstate the four fundamental needs. Long-term responses include how individuals respond after prolonged exposure to ostracism.

Finally, the last module is *Application of the model to sources*: motives, quantity, effects on fundamental needs, temporal related consequences. This module allows for the examination of ostracism and its impact on the source, because most likely the source is affected by the ostracism episode as well.

This model is useful in outlining and categorizing the consequences of exclusion on the target(s) and allows for testable predictions to be developed. The model focuses on the following: 1) the target's perception of ostracism, 2) explanations for the ostracism, 3) how targets can vary in sensitivity to ostracism, 4) target's reactions to ostracism, 5) and the length of exposure to ostracism.

Each chapter on exclusion will emphasize a portion of the model and will ultimately add information to the model and below I will provide a brief synopsis of each chapter.

Chapter 2 introduced and described the methodology used in this thesis and provided justification for the use of that methodology. Chapter 3 examined how individual differences in social cognitive style impacted responses and sensitivity to exclusion. Baron-Cohen (2003) argued that social cognitive style could be measured on a continuum from extreme empathizing to extreme systemizing (See also Baron-Cohen, 2002; Baron-Cohen, Ring, Wheelwright, Bullmore, Brammer, Simmons, and Williams, 1999). It is presumed that division of labour and evolutionary pressures from our ancestral environment caused a relative split in "brain type" leading to a specialization of cognitive style. Men typically present the systemizing style whereas women present the empathizing style. Because empathy has been linked to successful perceptions of social cues during interpersonal interaction, I hypothesized that individuals on the empathic end of the continuum would demonstrate and increased sensitivity to exclusion as evidenced by a significant decrease in fundamental needs: belonging, control, self-esteem, and meaningful existence. Furthermore, I hypothesized

that individuals on the systemizing end of the continuum would demonstrate a decreased sensitivity to exclusion compared to empathizers; moreover, there would be a significant difference in the fundamental needs of excluded individuals, which is connected to the empathizing and systemizing continuum.

Chapter 4 addressed the question, how does exclusion impact cognitive processing? This chapter applies to the *Reactions to Ostracism* module of Williams' model and specifically pertains to the immediate reactions, which often include negative affect, physiological arousal, anger, and hurt feelings (Williams, 2001). Baumeister, Twenge and Nuss (2002) argue that social exclusion reduces intelligent thought and that attention is usurped by exclusion causing participants to show a decrease in memory and overall "intelligence" immediately following the threat of exclusion. Herein cognitive function (measured by response time) on an emotional Stroop task was assessed. The goal of this study was to ascertain whether or not exclusion impacted cognitive-emotional function, or impacted one's response time on the emotional Stroop task. Because past research has shown that exclusion impacted intellectual function (scores on an intelligent test and memory), this study investigated whether other components of cognitive processing were also impacted. I hypothesized that cognitive function would be impacted by social exclusion. Specifically, those individuals in the exclusion condition would demonstrate a slower response time on an emotional Stroop task and participants in the inclusion condition would show an unaffected response time, compared to those in the exclusion condition, demonstrating that attention and cognitive performance are impacted by social exclusion.

fMRI was employed to investigate the neural correlates of social exclusion and their relevance to in and out-group membership in Chapter 5. The findings in this chapter pertain to the *Antecedents* and *Mediators or Moderator* components of the aforementioned model. It applies to

Antecedents as it manipulates physical characteristics of the source of exclusion, namely their race and degree of self-resemblance. Also, the race of the target acts as a moderator as their impression of the excluder may be impacted by their shared race or different race. Evidence has shown that individuals have a strong response to exclusion evidenced by increased activation in the dACC (Eisenberger, Lieberman, and Williams, 2003; Eisenberger et al., 2007). Cues like race and gender are often used as cues to determine group membership. I hypothesized that brain activation in the dACC would increase and fundamental needs would decrease when in-group members excluded participants, compared to exclusion from out-group members. Overall, I hypothesized that impact on the fundamental needs and activation in the dACC would be on a continuum with the greatest decrease in fundamental needs and increase in dACC activation occurring when the participant was excluded in the self-resemblance condition and the smallest decrease in fundamental needs and increase in dACC activation occurring during the other-race exclusion condition.
The last data chapter discussed another fMRI study, this time using hyperscanning (Montague et al., 2002) technology where two participants are scanned simultaneously. This experiment deviated from the aforementioned model of exclusion; however as I attempted to explain in the paragraphs preceding this (See Section 1.6., Figure 1.1.), exclusion and cooperation are related and may be considered to have a symbiotic relationship where cooperation acts as a reward and exclusion acts as a punishment. Chapter 6 speaks to the question of what happens in the brain when individuals cooperate. I hypothesized that when two people cooperated to complete a maze task, particular areas of the brain involved in theory of mind and reward would be activated compared to when participants worked alone to navigate through the maze. In particular, when participants completed the maze by working together, activation in

reward centres of the brain would be significantly stronger than when the maze was completed alone.

Finally, Chapter 7 provides a discussion of the four experiments. In this discussion I make interpretations and draw conclusions in order to describe a "big picture" application for this research programme and its application in the field of evolutionary psychology. Additionally, possible directions for additional research are discussed.

Chapter 2 Description of Methodology and Justification for Its Use

Throughout ostracism research several different methods of generating and examining exclusion have been utilized with regularity. Herein I review the most popular methods, describe the methods I used, and provide a justification for my use of these methods.

2.1. Ostracism and Social Exclusion Paradigms

Several different paradigms for investigating social exclusion and ostracism populate the literature. All of these paradigms, as different as they may seem, engender similar feelings of social exclusion. Each experimental paradigm discussed below has yielded meaningful inferences about the nature and consequences of exclusion; however researchers do not make the claims that these paradigms are the precise equivalent of ostracism experiences that occur in everyday life. Despite that, the following paradigms are considered to be valid and reliable, and have been used in a multitude of studies examining different facets of social exclusion.

2.1.1. Life Alone Paradigm

The life alone paradigm is an exclusion paradigm created by Twenge et al. (2001) and Baumeister et al. (2002). This paradigm incorporates a personality test that assesses introversion and extraversion characteristics. This, however, is just a front for the exclusion portion of the paradigm. Participants are given accurate feedback regarding their personality type; however then they are randomly assigned to a future alone condition, future belonging condition, or misfortune control condition all the while believing that they have been placed based on their personality assessment.

The future alone condition is the exclusion condition. Participants in the future alone/exclusion condition are informed that the personality test revealed that while they have friends and social relationships now, in the future these relationships will dissolve and they will end up alone. In the inclusion condition (future belonging) participants were told that they would continue to have positive relationships with others, and that they will most likely have a long and stable marriage. Lastly in the misfortune control condition, participants were told that they are likely to be very accident-prone in the future. This third condition is the control condition, and while it has a negative implication for the person's physical well being in the future, there is no mention of any social failure. This particular paradigm has been utilized in the investigation of aggression and social exclusion as well as in the examination of emotional responses to social exclusion. Results have indicated that this paradigm is successful in engendering feelings of exclusion, and it is a paradigm that is used frequently in the study of social exclusion.

2.1.2. The Getting Acquainted Paradigm

This paradigm is similar to the aforementioned paradigm. This paradigm excludes participants based on ostensible ratings from other group members (Nezlek et al., 1997). Participants partake in the study under the guise that they are participants in research about decision-making. Initially, individuals complete an information exchange questionnaire (consisting of the self-rating scales and writing of two self-reflective paragraphs) and then other participants in the cohort review this (Williams, 2007). Participants do actually rate each other's essays on likeability as planned. However, these ratings are not used. All of this elaborately sets up the scenario for the exclusion condition to be introduced. In the exclusion condition researchers report back to participants and tell that individuals either chose to work with them in a small group or that they were not

selected by others to be part of a group. For the latter they are informed that they must work alone. In the non-exclusion condition participants are told that they were randomly selected to be part of a group or to work alone. These two conditions are then compared to investigate the effects of purposeful exclusion versus random assignment to working alone (Williams, 2007).

2.1.3. Face-to-Face Ball Toss Game

Participants take part in a three way ball toss game. Two of the players are confederates and are told by the experimenter whether to include or exclude the participant. The participant is unaware that the ball toss game is pre-planned and that the "other players" are actually research confederates. In the exclusion round participants are included in a few rounds of tossing and catching. However, after a brief period of time passes the participants are excluded and the confederates no longer pass the ball to them. In the inclusion round participants receive and toss the ball continually throughout the game. I will discuss this paradigm in more detail in Section 2.2., where I explain why I elected to use a computerized version of this paradigm rather than carry out the face-to-face ball toss game.

2.1.4. Cyberball

Cyberball (Williams et al., 2002) is a computerized ball toss game. In this virtual version of the face-to-face ball toss game participants play a ball toss game ostensibly with two other players (See Figure 2.1.). The game can be programmed to randomly include or exclude participants. I will provide a more detailed description of Cyberball and its use in research in Section 2.2.

2.2. Comparison of the Face-to-Face Ball Toss and the Cyberball Paradigm

Almost a decade ago, Cyberball (Williams, Cheng, and Choi, 2000) was developed as an alternative to a face-to-face ball toss paradigm (Williams 1997) used to investigate social exclusion and ostracism. While the face-to-face game produced a robust outcome as far as engendering feelings of exclusion, Williams, Cheng and Choi (2000) created this computerized ball toss game in order to avoid several of the difficulties with implementing the face-to-face ball toss paradigm. To fully understand the benefits of Cyberball, it will be helpful to examine first the details and difficulties of the face-to-face ball-tossing paradigm.

The face-to-face ball toss game proceeds in the following way: participants are asked to wait in a waiting room with two other participants (actually two confederates) and one of these confederates begins tossing a ball around. In the inclusion condition the ball is tossed between all three people. However, in the exclusion condition the confederates exclude the participant from the game after several tosses. The first difficulty that Williams described was the "cumbersome and inefficient" nature of the face-to-face ball toss game (Williams and Jarvis, 2006). It is very time consuming to recruit and train the confederates in addition to creating the scenario that accompanies the experiment. Second, aside from training, the use of confederates raises some specific concerns in this paradigm, because the task of ignoring another is challenging and likely experienced in an individually different manner that is beyond scientific control. That is, the ability to control the behaviour of the confederates from day to day severely limits the experimental control of this paradigm. It has been documented that the targets' responses can be very different; therefore, ostracism can be idiosyncratic (Williams, 2001). Furthermore, the authors noted that the confederates first treated the exclusion episodes sympathetically, but eventually they began to approach them with "sadistic

glee" (Williams and Jarvis, 2006, p. 174). This description sounds vaguely reminiscent of the types of attitudes that occurred in the Stanford Prison (Zimbardo et al., 1973) experiments and the infamous experiments on coercion conducted by Stanley Milgram (1963) where individuals in both of those experiments became very absorbed in their roles and were later remorseful about the behaviours they had exhibited while playing that role. Because of these experimental and ethical drawbacks and complications with using the face-to-face paradigm, Williams and colleagues developed Cyberball as an alternative method for investigating social exclusion. Cyberball is a computerized version of the ball toss game that was developed to eliminate the need for the use of confederates and to lessen the "traumatic nature" of the paradigm for participants (Williams, 2007). Since the creation of Cyberball, it has been used extensively in the investigation of social exclusion and ostracism. The first study using the Cyberball paradigm included a cross-cultural sample of over 1,400 participants (Williams, Cheung, and Choi, 2000).

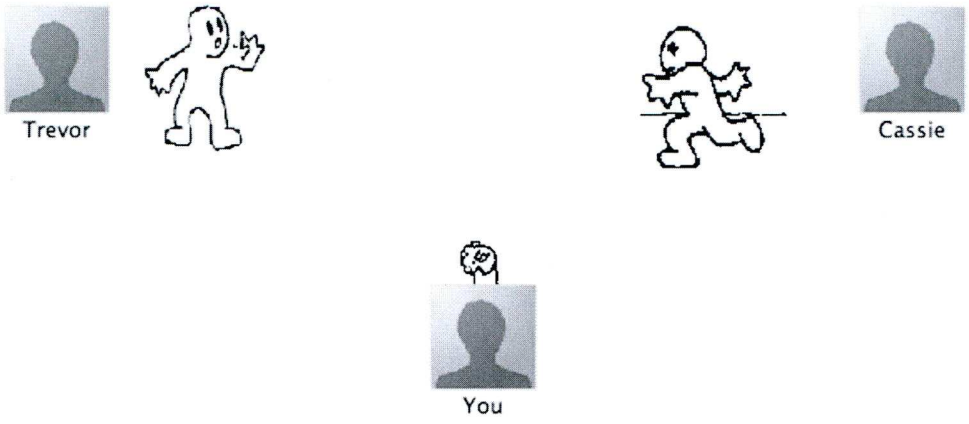


Figure 2.1. Cyberball Game Screen Shot

The game was set up online so that participants could log on and play either a virtual disk tossing game or a ball tossing game. In each of these studies, participants tossed the ball ostensibly with two other players whom they

believed were other internet players. Participants were randomly assigned to different degrees of inclusion: over-inclusion, inclusion, partial-exclusion, and total-exclusion conditions. In the over-inclusion condition participants were included in over half of the throws, while in the inclusion condition participants received one third of the throws. In the partial exclusion condition participants received one sixth of the tosses, while in the total exclusion condition the ball was not tossed to them at all during the game. Participants in the total-exclusion condition, who did not receive any tosses of the ball, reported significantly lower levels of satisfaction of four needs in the post experiment questionnaire.

Despite some concern that the Cyberball paradigm would be negligible, because the game was played over the computer with individuals who the participant has no relationship with, results indicated that it produced robust results. Participants in the inclusion conditions exhibited more positive responses in the post game questionnaire compared to participants who received a mere one sixth of the tosses (exclusion condition). Participants in the total-exclusion condition, who did not receive any tosses of the ball, reported significantly lower levels of satisfaction of four needs in the post experiment questionnaire. Moreover, Cyberball has demonstrated significant effects not only in this study but also in at least a dozen subsequent studies (Williams, 2001; Eisenberger et al., 2006; Zadro et al., 2004; Van Beest and Williams, 2006; Eisenberger et al., 2003, Gonsalkorale and Williams, 2007; Zadro et al., 2006; Eisenberger et al., 2007; Jarva and Oinonen, 2007; Oaten et al., 2008; Masten et al., 2009) including two studies that I have led and published (Krill et al., 2008; Krill and Platek, 2009).

Participants demonstrate strong effects in their responses on the post-experimental questionnaire that assesses participant satisfaction on four fundamental needs (belonging, self-esteem, control, and meaningful existence). Large effect sizes, ranging from 1.0 to 2.0, have been reported

(Williams, 2007). In fact, Williams and Jarvis (2006) report that as few as three participants per condition are needed to reach levels of significance ($p = .05$) on the post experimental questionnaire.

Questions have been raised about how meaningful or distressing exclusion from a computerized game (played with people that one never expects to meet or come in contact with) can actually be. Aside from the aforementioned cross-cultural study (Williams et al., 2000), there are many other studies that provide support for the success of Cyberball (Williams, 2001; Eisenberger et al., 2006; Eisenberger et al., 2004; Zadro et al., 2004; Van Beest and Williams, 2006; Eisenberger et al., 2003, Gonsalkorale and Williams, 2007; Zadro et al., 2006; Eisenberger et al., 2007; Jarva and Oinonen, 2007; Oaten et al., 2008; Masten et al, 2009). Zadro et al. (2004) conducted a study where participants were informed that they were playing Cyberball against other players or against a computer. There was no significant difference on the post-experimental questionnaire between the groups that were excluded by the other players or by the computer program. This suggests that exclusion and ostracism has an impact regardless of the source of exclusion.

Several studies have made comparisons between Cyberball and other social exclusion experiences. Eisenberger et al. (2007) used fMRI to investigate the neural correlates associated with being excluded in Cyberball. They discovered that the areas of the brain that become active in response to real life social and emotional experiences were also activated in response to being excluded while playing Cyberball. Additionally, MacDonald (2008) investigated the relationship between social exclusion and pain threshold. He used Cyberball in one experiment and a rejection recall writing task in the other experiment. Results indicated no significant difference in response to pain between the two social exclusion experimental manipulations. However, differences in attachment style did interact with pain threshold in the rejection recall study, but did not in the

Cyberball study. The author attributed these differential findings to the control task that was used in the study. The baseline pain rating was used as a control, but the author hypothesizes that as participants became more comfortable in Study 1 they were less likely to keep up the appearance of pain insensitivity. However, in Study 2 there was less opportunity for participants to become comfortable in the surroundings. Thus participants in Study 2 kept up the pain insensitivity façade. Most importantly, despite the difference in the control/baseline condition in each study, the experimental condition, whether it is Cyberball or writing recall task, produced the same results.

Cyberball is by no means an experimental tool that is without flaw. There are a few methodological limitations associated with Cyberball, just as there are with any experimental paradigm. Running Cyberball through the internet and recruiting participants from the internet raises a few concerns: researchers are unable to control the conditions of participation, people can be dishonest about their identity (e.g. demographic information), and can also attempt to take part in the experiment more than once. However, it is possible to track participation time and network location confidentially (i.e. IP address) which allows researchers to control for multiple participation. Aside from this, very few criticisms of Cyberball are evident in the literature. A study assessing group member relationships and motivation made the assertion that the Cyberball game is not a particularly effective means of creating cohesion among social groups. While this is in an important limitation of the game it is not one that affects the focus of my research. Additional limitations in use of the Cyberball game will be discussed at the end of the chapter.

Cyberball has been shown to be a valid and reliable task used to engender social exclusion (Williams and Jarvis, 2006). While it is a convenient and effective social exclusion task, it is not the only kind of social exclusion task that has merit. The triadic face-to-face ball toss game does provide a

very realistic scenario for social exclusion, and the social exclusion writing recall task works, as well. However, for the intents and purposes of my thesis Cyberball was the task that had the best fit for my research due to its inherent flexibility in use. It would have been ideal, if not encumbered with financial and time constraints, to run my studies using all three of the major exclusion methodologies. However, that was not an option. With the wide spread use of Cyberball, and the plethora of research supporting its effectiveness and ease of use, I felt confident using it in my studies. I used Cyberball not only in the behavioural realm, but also to assess the neuropsychological components associated with social exclusion. Examining social exclusion from these different approaches gives a more in depth look at social exclusion and demonstrates the versatility of Cyberball.

2.3. Functional Magnetic Resonance Imaging

Functional magnetic resonance imaging (fMRI) allows for the detection of brain areas that are involved in a process, task, or emotion, and I used this methodology in two of the studies included in this manuscript. It works by detecting the increase in blood flow to the vasculature that is associated with neural activity in the brain (Matthews, 2001). The blood oxygenation level dependent effect (BOLD effect) provides a comparative measurement of oxygenated versus deoxygenated haemoglobin (Gjedde, 2001). In other words, this measure is then used to determine what areas are the most active in the brain. Oxygenated haemoglobin does not have as much impact on the magnetic field of the fMRI scanner. However, deoxygenated haemoglobin does significantly impact the magnetic field. As activity in the brain increases, deoxygenated haemoglobin decreases, this enhances the variation in magnetic haemoglobin creating the BOLD signal. Since fMRI is not designed and is not capable of detecting "absolute neuronal activity" in the brain, it is used to detect the difference in brain activity (or

BOLD signal) between a set of experimental conditions. Participants are usually exposed to several experimental conditions and then a comparison is made between the conditions to assess activation (Matthews, 2001).

2.3.1. fMRI Paradigms

During the fMRI experiment participants are typically required to perform a series of tasks. These tasks are often alternated between an experimental condition and a control or distracter condition (Donaldson and Buckner, 2001). These conditions are usually repeated several times and are often separated by rest periods, which make up the fMRI paradigm. Most often the stimuli used are audio or visual stimuli, however, the stimuli can also include taste, odour, and tactile stimuli.

I used fMRI in two studies incorporated in this thesis. The ability to examine neural correlates along with the behavioural component makes fMRI a very special tool in psychological research. However, fMRI is not without criticism (Matthews, 2001). For instance fMRI has been criticized as a secondary measurement of physiological activity. This is true, however, that does not discredit the information that fMRI does provide. fMRI provides an in depth look at brain function, not an exact measurement of mental activity, but paired with behavioural information it can provide a clearer picture as to what is occurring neurologically in response to the experimental question being investigated. Additionally, the temporal resolution or timing of fMRI is not as fast as other methods like EEG. I elected to use fMRI in these studies because I was very interested in the spatial localization of function. In the future I believe that ostracism research could benefit from an examination of the timing (temporal resolution) of brain function. Lastly, it can be said that fMRI research is prone to localization, examining only one area instead of a network. I attempted not to isolate structures, but to look for a complete set of structures working together to complete the task by using different

comparison of brain activity during different tasks. I did not use, however, connectivity modelling. Overall, I think that fMRI is a very useful tool for psychological research. Because fMRI data is very sensitive and personal material, all data was handled in an appropriate manner following the rules and regulations enforced by the University of Liverpool and MARIARC.

2.4. Measures

2.4.1. Fundamental Needs Questionnaire/Social Exclusion Questionnaire

In all of the exclusion studies in this thesis, I have elected to use the Fundamental Needs Questionnaire/Social Exclusion Questionnaire (Williams, Chang, and Choi, 2000; See Appendix 1.1.) to assess the impact of social exclusion on four fundamental needs. The following is a description of the measure and of the characteristics that are calculated. The theory behind this questionnaire assumes that exclusion uniquely targets and threatens four distinct fundamental needs. These needs are belonging, control, self-esteem, and meaningful existence. This post-experimental questionnaire is used to measure the degree to which participants were impacted by exclusion or inclusion. Lower ratings on the fundamental needs indicate that the level of those needs have decreased compared to participants that were included. Participants rated their response on a nine point scale ranging from 1= not at all and 9= always. The first part of the questionnaire contains a manipulation check, which is used to assess whether or not the participant actually realized that they were excluded or included. The questions in the manipulation check include the following questions: "What percent of the throws were thrown to you?" and "To what extent were you included by the other participants during the game?" These questions are an important addition to the questionnaire, as it is essential to know whether or not participants actually realized whether they were included or excluded in the study. The

questionnaire also contains a series of questions that ask participants to assess their level of satisfaction of four needs that they felt while they were playing the game. The first group of questions pertains to the need to belong. These questions include the following: "I felt poorly accepted by the other participants," "I felt as though I had made a connection or bonded with one or more of the participants during the Cyberball game," and "I felt like an outsider during the Cyberball game." Control is the next need that is assessed. Questions include the following: "I felt like I was able to throw the ball as often as I wanted during the game," "I felt somewhat frustrated during the game," and "I felt in control during the Cyberball game." Self-esteem is another need assessed by the questionnaire. The self-esteem portion of the questionnaire includes the following questions: "During the game I felt good about myself," "I felt that the other participants failed to perceive me as a worthy and likeable person," and "I felt somewhat inadequate during the Cyberball game." Finally, meaningful existence is the last need that is included in the questionnaire. Meaningful existence is assessed by the following questions: "I felt that my performance (e.g. catching the ball, deciding whom to throw the ball to) had some effect on the direction of the game," "I felt non-existent during the Cyberball game," and "I felt as though my existence was meaningless during the Cyberball game." Participants were asked to rate their mood. They were given choices from the following list: bad, good, happy, sad, relaxed, tense, aroused, and not aroused. Additionally, two supplementary variables (or questions) were added the end of the questionnaire. These questions are "I felt angry during the Cyberball game" and "I enjoyed playing the Cyberball game." Limitations of the questionnaire will be discussed at the end of the chapter.

2.4.2. Rejection Sensitivity Questionnaire (RSQ)

I used the Adult Rejection Sensitivity Questionnaire (A-RSQ) (Downey, Berenson, and Kang, 2006) to measure rejection sensitivity among participants (See Appendix 1.2.). Downey and Feldman (1996) describe The Rejection Sensitivity Questionnaire (RSQ), the precursor to the A-RSQ: "This measure operationalizes rejection sensitivity as generalized expectations and anxiety about whether significant others will meet ones' needs for acceptance or will be rejecting" (p. 132). The measure contains questions that involve expressing a need or a desire to an important other, and it is believed that this possible vulnerability should elicit rejection anxiety and expectations from those who have an increased sensitivity to rejection.

Participants are presented with nine scenarios. Some involve family and friends and romantic partners, while others involve strangers. In each scenario participants are asked to imagine that they are making a request of someone: for instance, "You call a friend when there is something on your mind that you feel that you really need to talk about." Participants are then asked how concerned they would be about the response to what they are asking and whether they would expect the person they are asking to accept or reject their request. In the development of the original Rejection Sensitivity Questionnaire, from which the A-RSQ was derived, young adults (college students) were asked to identify situations that were relevant to their lives. The scenarios included in the RSQ are designed to target that population and were developed from interviews with 20 young adult students. I elected to use the Adult Rejection Sensitivity Questionnaire (A-RSQ) questionnaire, as I thought that it was more generalizable to a variety of age groups. Several of the studies for my thesis were conducted online; therefore, I did not have control over the age of my participants. I felt that the A-RSQ would be a better choice to reach a larger age group. Additionally, while many of the participants were

students, they were graduate students and I felt that there was a distinction in age and maturity of graduate students versus undergraduate students, so the A-RSQ seemed more appropriate for graduate students.

The A-RSQ was created "by revising situations on the RSQ to have more generally applicable wording, removing those that were specific to college life, and generating additional items about potential rejection situations in adults' lives. The 9-situation Adult RSQ (A-RSQ; Downey, Berenson, & Kang, 2006) correlated .87 with the original college based 18-situation RSQ among students" (Berenson et al., 2009).

As I mentioned previously, the responses to the scenarios provided vary along two dimensions. The first dimension is the degree of anxiety or concern about the outcome. The second dimension is the expectation of rejection or acceptance (Downey and Feldman, 1996). Systematic covariation along these dimensions is common. Some participants respond that they are anxious about making the request, but do not expect to be rejected. Other participants with high anxiety about making the request do report a similarly high level of rejection expectation. Participants rate their level of concern on a 6 point scale (1= very unconcerned to 6= very concerned). The likelihood of rejection is also measured on a 6 point scale (1=very unlikely to 6=very likely). Expectations of rejection are represented on the very likely end of the scale.

The validity of the A-RSQ has been demonstrated (Berenson et al., 2009). The authors reported that the A-RSQ was completed by 685 participants and that the results were consistent among genders and age groups. There was however some variation with level of education. After controlling for level of education the A-RSQ correlated with the following constructs: neuroticism, social/avoidance distress, self-esteem, attachment anxiety and attachment avoidance, and interpersonal sensitivity and depression (Berenson et al., 2009). Berenson et al. (2009) reported that the A- RSQ has high internal validity ($\alpha = .74$). The Adult RSQ (A-RSQ) has the

following characteristics: Mean = 8.99 and Standard Deviation = 3.60; (Berenson et al., 2009).

In some instances it may seem that the questions on the RSQ and A-RSQ are phrased differently, and this difference could impact one's perception of the question. For instance, in some of the questions from the A-RSQ suggests a motive for the meeting between the individual and the significant other ("...you call or approach your significant other because you want to make up) whereas the scenario from the RSQ does not mention wanting to make up, just that the person wants to see the other ("You call your boyfriend/girlfriend after a bitter argument and tell him/her that you want to see him/her"). While this concern may have some validity, the purpose of the RSQ (and the A-RSQ), as stated in the article by Downey and Feldman (1996), is to assess vulnerability and rejection anxiety when one in placed in situations that involve expressing a need or a desire to a significant other. Therefore, in the A-RSQ scenario, a need or desire to make up is expressed. The scenario is in accordance with the intentions of the measure as it expresses a need or desire. The authors continue on to state (Downey and Feldman, 1996), "Thus, situations that involve expressing a need to a significant other should be particularly likely to activate generalized reaction anxieties and expectations, thereby revealing the extent of a person's sensitivity to rejection" (p.1329). Furthermore, the fact that the A-RSQ correlated .87 with the RSQ suggests that regardless of minor differences in wording and semantics, the two measures are similar.

The RSQ and the A-RSQ are scored the same way. A score of rejection sensitivity is calculated for each situation by multiplying the response to level of rejection concern by the response to acceptance expectancy (7-acceptance expectancy). A mean is calculated for the scores for each item and this produces the overall rejection sensitivity score.

2.5. Analysis

Two main software tools were used in the analysis of my data. I used the Statistical Package for Social Sciences (SPSS) to analyze behavioural data and FMRIB Software Library (FSL) (Smith et al., 2004) for the analysis of brain imaging data.

2.6. Conclusion

Hopefully, this overview of the methods used in the studies incorporated in this thesis provides clarification for the reader, prevents repetition throughout the manuscript, and provides a place to refer back to while reading the data chapters to follow. Based on the background information and existing research, the methods used in this thesis appear to be valid and reliable tools and are suitable for the studies as they were executed in this programme of research.

While all of these measures appear to be valid and reliable that does not mean that usage makes for a flawless design in all of the studies. For instance, one major problem exists with the use of Cyberball and the post-experimental questionnaire. These measures are both valid and reliable measures, but without a pre-experimental measure to assess the fundamental needs prior to the experimental conditions one cannot say without exception that the results or differences between the inclusion and exclusion groups are the result of a decrease in the four fundamental needs. For instance, throughout this thesis, it was my goal to show that individuals exposed to exclusion were negatively impacted, and subsequently, excluded participants demonstrated a decrease in the four fundamental needs, but one cannot make that claim because there is no data concerning baseline measures of the fundamental needs. Without the inclusion of the pre-experimental measure one might as easily say that participants in the inclusion condition showed an increase in the four fundamental needs. This is a limiting factor of the measures used throughout this thesis. Given the

previous research done on social exclusion and all of the existing literature (Williams, 2001; Eisenberger et al., 2006; Eisenberger et al., 2003; Zadro et al., 2004; Van Beest and Williams, 2006; Gonsalkorale and Williams, 2007; Zadro et al., 2006; Eisenberger et al., 2007; Java and Oinonen, 2007; Oaten et al., 2008; Masten et al., 2009; Krill et al., 2008; Krill and Platek, 2009), evidence suggests that it is not likely that participants would demonstrate an increase in the four fundamental needs and demonstrate no effect when excluded, but given my results I cannot confirm that this is the case. These alternative explanations for the findings herein are important to mention, but I maintain that the differences between the fundamental needs are most likely related to the experimental condition. Furthermore, the utilization of the experimental design set-up, that I used throughout, has been used over a dozen times and has been used for over 10 years in social exclusion research (Williams, 2001; Eisenberger et al., 2006; Eisenberger et al., 2003; Zadro et al., 2004; Van Beest and Williams, 2006; Gonsalkorale and Williams, 2007; Zadro et al., 2006; Eisenberger et al., 2007; Java and Oinonen, 2007; Oaten et al., 2008; Masten et al., 2009; Krill et al., 2008; Krill and Platek, 2009). While it may not be without flaw, it is a commonly used and positively regarded paradigm in social exclusion research.

In the upcoming chapters I am going to describe four studies, which utilize some or all of the methods and measures described in this chapter.

Chapter 3 The Impact of Cognitive Style on the Experience of Social Exclusion During the Cyberball Game

3.1. Introduction

This chapter describes an experiment designed to investigate how empathizing and systemizing cognitive styles (cf. Baron-Cohen, 2003) account for variation in the experience of social exclusion (self-reported distress and four fundamental needs) during an internet ball toss game.

3.1.1. Social Exclusion

Social exclusion is the act of being excluded, rejected, or ostracized by others without explicit explanation or negative attention. Within the context of this, it can also be described as the reflexive experience of distress as result of an actual or perceived psychological or physical distance from others (Williams, 2007; Eisenberger et al., 2003; see also Gruter and Masters, 1986 for a review). Additonally, social exclusion has the unique ability to threaten four fundamental human needs: belonging (Baumeister and Leary, 1995), self-esteem (Baumeister, 1994; Leary, 1990), control (Seligman, 1975), and meaningful existence (Williams, 2007; 2001). The importance of the aforementioned needs for motivation, self-efficacy, and even survival has been supported in the literature (Baumeister and Tice, 1990; Williams, Cheung, and Choi, 2000). Evidence has also shown that individuals seek to increase their sense of belonging, control, self-esteem, and meaningful existence (Baumeister and Tice, 1990). When these needs are lacking individuals experience pathological effects that are more significant than an impulsive distress response (Baumeister and Leary, 1995). In one study (Eisenberger, Lieberman, and Williams, 2003), participants observed a scenario that emulated exclusion as well as experiencing a real exclusion condition while they were in an

fMRI scanner. While activation was the strongest during the exclusion round, results indicated that the same parts of the brain were activated during the observed round as were activated during the exclusion round. This suggests that participants do not actually have to be purposefully excluded to be negatively affected by exclusion (Eisenberger and Lieberman, 2004; Eisenberger et al., 2003; Williams, 1997).

Zadro and colleagues (2004; see also Williams, Cheng, and Choi, 2000) randomly assigned participants to play a ball toss game, Cyberball, (Williams et al., 2000; Williams et al., 2002) with a computer or with another human via an internet connection. They discovered that individuals reported a decrease in the four fundamental needs (i.e. belonging, control, self-esteem, and meaningful existence) after exclusion from the ball toss game, independent of whether or not the individual believed that they were excluded by the computer or another human being. Thus, social exclusion appears to have a pervasive negative impact upon the target regardless of the intention or the source of the exclusion.

Social exclusion is likely to have been of great evolutionary significance both to the group and to excluded individuals. It may have been evolutionarily adaptive for a group to exclude certain individuals as a way to maintain group cohesiveness. Kurzban and Leary (2001) suggest that ostracism goes hand-in-hand with punishment, and has evolved as a mechanism to protect group members from individuals who violate social norms (e.g. incest) or group rules (Barner-Barry, 1986; Gruter and Masters, 1986). For the individual, exclusion can have dire consequences (Gruter and Masters, 1986; Kurzban and Leary, 2001). Excluded individuals can become cut off from resources and from protection by the group. The potential danger of social exclusion may have led to the development of a response system designed to prevent and counteract social exclusion. Those individuals who are more perceptive to ostracism may have an

advantage in that they can act quickly to avoid exile from the group (Williams, 2007).

Decreases in the four fundamental needs (Williams, 2001) as well as the onset of feelings of distress, humiliation, sadness, and anger, are examples of the types of motivational and emotional mechanisms that might drive behavioural changes aimed at avoiding social exclusion or regaining inclusion in the group (Robertson, Delton, and Klein, 2006; Williams, 2007). When individuals are excluded or threatened with exclusion they experience distress, which has been called social pain (Eisenberger, et al., 2003; Eisenberger and Lieberman, 2004). However, despite the potentially hardwired nature of this response, there is no evidence as to whether this distress response varies as a function of individual differences in social cognition. Here I investigated whether proclivity to empathize or systemize had any bearing on the perception and experience of social rejection. According to Williams' model (See Chapter 1, Section 1.6. for a review), cognitive style (e.g. brain type, discussed below) is classified under the *Moderator and Mediator* module of the model; as it is an individual difference of targets that may impact the outcome of exclusion. I tested this part of the model.

3.1.2. Empathizing-Systemizing Hypothesis

The Empathizing-Systemizing theory (Baron-Cohen, 2002; Baron-Cohen, 2003; Baron-Cohen and Hammer, 1997) claims that the female brain is principally predisposed towards empathizing and the male brain is principally predisposed towards systemizing (Baron-Cohen, 2003; Goldenfeld, Baron-Cohen, and Wheelwright, 2005). Empathizing can be defined as "the drive to identify another person's emotions and thoughts and to respond to these with an appropriate emotion" (Baron-Cohen, 2003, p. 3). A key component to empathizing is theory of mind (ToM), which is critical for the detection of information pertaining to the mental state,

emotions, and intentions of others and to recognize how another's feelings may impact oneself (Bachevalier and Loveland, 2006). Without ToM there would be considerable difficulty in changing one's behaviour in response to cues and changes in another individual's behaviour or emotional state. This does not imply that individuals who rank low on empathy are ToM impaired, but there appears to be an important link between empathy and ToM. Empathy has been hypothesized as an essential key to the development and maintenance of human relationships (Baron-Cohen, 2003).

Females tend to be better at empathizing than males (Baron-Cohen, 2003; Goldenfeld et al., 2005). Baron-Cohen (2003) suggests that this sex difference is related to the evolutionary hypothesis for division of labor in hunter-gatherer societies. Baron-Cohen (2003) writes, "Some theories suggest that our male and female ancestors occupied quite different niches and had very different roles. If true, the selective pressures are likely to have been very different for each, and could have led to the evolution of different types of cognitive specialization" (p.117). It is easy to imagine how empathizing would be beneficial to mothering and to living peacefully in a small community, because it is a critical component in sociality and relationship maintenance. In fact, many of the advantages gleaned by superior empathizers are directly related to social inclusion, or alternatively avoidance of social exclusion.

Systemizing, the other endpoint of Baron-Cohen's (2003) brain-type continuum, is the drive to understand a *physical* system. Additionally, the drive to build a system is also an important part of systemizing. There are many types of systems such as mathematics, machines, music, climate, economics, etc. These systems have one thing in common: a set of rules. Once the rules governing the system are known, they can be used to make accurate predictions about the system (Baron-Cohen, 2003; Baron-Cohen, Wheelwright, Burtenshaw, and Hobson, 2007). Systemizing parallels

empathizing in two ways: 1) individuals can have differing degrees of systemizing, and 2) it is believed to have been selected for during evolution in a similar way as empathizing (i.e. through frequency-dependent selection based on sex-specific division of labor). The hypothesized advantages associated with increased systemizing ability include using and making tools, hunting, war strategies, social dominance and power, as well as tolerating solitude (Baron-Cohen, 2003). It is of particular interest that tolerating solitude is associated with increased systemizing ability. Individuals who are better at tolerating solitude would most likely be less driven to socialize and therefore they can devote more of their time to other activities. Baron-Cohen (2003) suggests that in pre-industrial societies, toleration of solitude might have been especially advantageous to hunters who had to go on long journeys in search of food. One might speculate that males who hunted for longer may conceivably have been more successful, which would have resulted in more food and increased chance of survival. Furthermore, the tendency to systemize may engender behaviour that isolates an individual from the rest of the group.

I hypothesized that individuals categorized as empathizers would report greater levels of distress as a result of being socially excluded during a ball toss game. Empathizers were predicted to show lower self-reported satisfaction levels of belonging, control, self-esteem, and meaningful existence. On the contrary, systemizers were predicted to report that they experienced less distress (self-reported satisfaction levels would not be impacted by exclusion) as a result of exclusion from the ball toss game. Specifically, I predicted that individuals at the extreme empathizing end of the spectrum would be most "distressed" by social exclusion, showing the lowest self-reported satisfaction levels of belonging, control, self-esteem, and meaingful existence; furthermore, indviduals at the extreme systemizing spectrum would be least "distressed" by the social exclusion condition. Individuals who fell into the balanced brain category, meaning

they are no more empathic than they are systematic, were predicted to report lower satisfaction levels on the four needs, but not to report levels as low as extreme empathizers or empathizers. Furthermore, I hypothesized, that balanced brain individuals would report more distress (lower satisfaction on the four needs) than extreme systemizers and systemizers.

3.2. Methods

3.2.1. Participants

One hundred and nineteen participants (72 females; 47 males; M_{age} = 32.49, SD = 11.63), were recruited from the internet (http://www.webexperiment.net) and university announcements system. Data were collected using online data collection software (Wathne and Platek, 2007). The University of Liverpool School of Biological Sciences Committee on Research Ethics approved the study. Participants were asked to indicate what discipline they studied or worked in, as this has been shown to correlate with systemizing and empathizing (Baron-Cohen et al., 2007; Focquaert, Steven, Wolford, Colden, and Gazzaninga, 2007). The Humanities group consisted of 39 individuals; the Sciences group consisted of 48 individuals. There were 32 participants who selected "neither". The majority of the individuals who selected "neither" entered their profession separately, some of which included adminstration, law, public safety, event planning, and finance.

3.2.2. Procedure

The sections below describe the methods and measures used in this study.

3.2.3. Empathizing – Systemizing Quotients

Participants completed the short forms of the Empathy Quotient (EQ-Short) (Wakabayashi et al., 2006) (See Appendix 1.3.) and the Systemizing

Quotient (SQ-Short) (Wakabayashi et al., 2006) (See Appendix 1.4.). The scores from the SQ-S and the EQ-S had to be converted into standardized (*T*) scores (see Wakabayashi et al., 2006 for more information). Then the the EQ-S (*T*) score was subtracted from the SQ-S (*T*) score. Thisresulting number is called the *D score*, as it accounts for the *difference* between the two brain types. A high *D score* (the difference between the SQ-S and EQ-S) denotes a systemizing cognitive style ($10 < D < 20$ is type S). A score above 20 is categorized as an *extreme* systemizing style. A low score (including negative scores) denotes an empathizing cognitive style ($-10 < D < -20$ is type E). *Extreme* empathizing style is categorized by a score of -20 and below.

3.2.4. Cyberball Parameters

After completing the EQ and the SQ participants played Cyberball (Williams et al., 2002; see Sections 2.1.4. and 2.2. for a review). The Cyberball game was modified so the game could be played over the internet. Cyberball was programmed to generate 60 tosses during each round and to delay each toss for 0.5 to 3 seconds in an effort to make the game seem realistic. Players were randomly assigned to either an inclusion round or an exclusion round. In the inclusion round, the subject was involved in playing the game (throwing the ball) with confederates (computerized opponents) throughout the duration of the game. In the exclusion round, the participants were allowed to participate during the beginning of the game (six throws). After six throws the game was programmed to stop tossing the ball to the participant; the participant saw the computerized confederates playing amongst themselves but no longer received a throw during this exclusion period.

3.2.5. Post game questionnaire

After the game ended, participants were asked to complete a questionnaire (Fundamental Needs Questionnaire/Social Exclusion Questionnaire, see Section 2.4.1. for a review) to assess their level of needs and distress while being excluded from the ball toss game (Williams et al., 2002; Zadro, et al., 2004). The questionnaire contained manipulation checks to ensure that participants who where excluded actually noticed that they were excluded. The questionnaire (Zadro et al., 2004) also contained questions that were designed to assess participants' levels of four basic needs during the game: *belonging*, *control*, *self-esteem*, and *meaningful existence.* Additionally, the questionnaire contained two questions about supplementary variables (i.e., 'I enjoyed playing the Cyberball game,' and 'I felt angry during the Cyberball game.') and mood. Participants provided their responses on a scale of 1 through 9 (1= not at all, 9= always). In some cases, questions had to be reverse scored, so that a higher score would be equivalent to a more positive response (e.g. the question "Overall in the last round, did you feel rejected by the other players?").

3.2.6. Debriefing

After participants completed the questionnaire the final screen in their web browser presented a debriefing statement about the experiment. Participants were informed that they had not been playing with real individuals and that the computer game had been programmed to randomly include or exclude participants. They were also provided with contact details for additional information or questions about their participation.

3.3. Results

3.3.1. Manipulation Checks and Fundamental Needs

There were three manipulation check questions included in the questionnaire. Participants in the exclusion condition reported feeling significantly less accepted and included, and more rejected, compared to participants in the inclusion condition ($F(1,117) = 225.7, p < .001, partial\eta^2 = 0.659$). Results indicate that participants were able to correctly identify their status of inclusion or exclusion during the game.

A multivariate analysis of variance (MANOVA) revealed that there was a main effect for the inclusion/exclusion conditions. There was, however, no main effect for sex of participant. Furthermore, there was no interaction between inclusion/exclusion condition and sex. Results also showed that participants in the exclusion condition reported lower levels of the fundamental needs with the exception of meaningful existence (*Belonging*, $F(1,118) = 123.4, p < .001, partial\eta^2 = 0.518$; *Control* = $F(1,118) = 76.1, p < .001; partial\eta^2 = 0.398$; *Self-Esteem* = $F(1,118) = 10.2, p = .002, partial\eta^2 = 0.081$; *Meaningful Existence* = $F(1,118) = 3.0, p = .089, partial\eta^2 = 0.025$). These results replicate those found by Zadro and colleagues (2004), with the exception of the meaningful existence variable not being significant (see Table 3.1.).

	Inclusion	***Exclusion***
Fundamental Needs		
Belonging	M=6.37; SD=1.05	M=3.45; SD=1.64
Control	M=6.06; SD=1.60	M=3.45; SD=1.53
Self-Esteem	M=6.95; SD=1.28	M=5.94; SD=1.85
Meaningful Existence	M=4.62; SD=0.88	M=4.33; SD=0.84

Table 3.1. Means and Standard Deviations of Variable Scores. Scores range between 1=not at all to 9=very much so; some items are reverse scored. [a] Each of the fundamental need scores represents an average of three questions from that category.

There were two supplementary variables in the questionnaire: "I felt angry during the Cyberball game" (reverse scored) and "I enjoyed playing the Cyberball game." These two questions were combined into a composite variable which I named the supplementary variable. An ANOVA revealed that participants in the exclusion condition reported significantly lower scores on the supplementary variable ($F(1,118) = 9.378$, $p = .003$, $partial\eta^2 = 0.272$). In other words, they were significantly more angry and experienced less enjoyment during the Cyberball game. Participants were asked to rate their mood on a sliding scale before the Cyberball game and again after the game was completed. Results indicated that there was no significant change in mood before or after the game no matter what condition participants were assigned to ($Fs < 1.0$, *ns*).

3.3.2. SQ, EQ and Inclusion vs. Exclusion Conditions

Analyses were run to determine whether there was a relationship between scores on the SQ-S and EQ-S (Wakabayashi et al., 2006) and level of distress (measured by the four fundamental needs) in the exclusion condition (See Table 3.2. for a breakdown of the frequencies of each brain-type category). A multivariate analysis of variance (MANOVA) showed that there was no interaction between sex and brain type. There was, however, a main effect for the *D score* on the *control* fundamental need variable (see 3.1.), but there was not a main effect for the *D score* on the other three fundamental need variables.

Table 3.2. Frequency of Males in Brain-Type Category

	Frequency	Percent	Valid Percent	Cumulative Percent
Empathizing	5	10.6	10.6	10.6
Balanced Brain	26	55.3	55.3	66.0
Systemizing	8	17.0	17.0	83.0
Extreme Systemizing	8	17.0	17.0	100.0
Total	47	100.0	100.0	

Table 3.3. Frequency of Females in Brain-Type Category

	Frequency	Percent	Valid Percent	Cumulative Percent
Extreme Empathizing	7	9.7	9.7	9.7
Empathizing	18	25.0	25.0	34.7
Balanced Brain	40	55.6	55.6	90.3
Systemizing	5	6.9	6.9	97.2
Extreme Systemizing	2	2.8	2.8	100.0
Total	72	100.0	100.0	

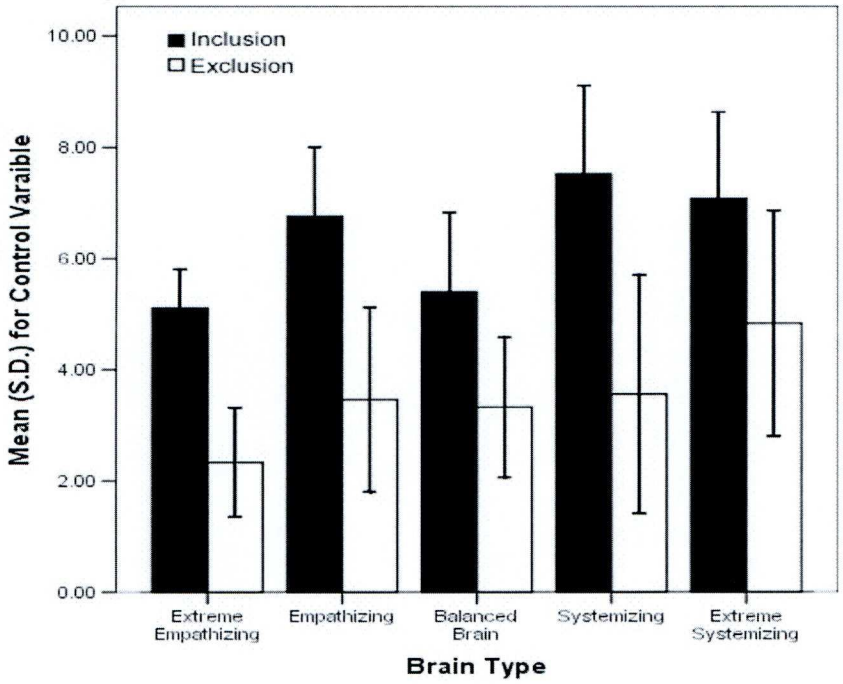


Figure 3.1. Cognitive Style and Control. Mean (±S.D.) control variable score as a function of cognitive style.

A Bonferroni post hoc analysis illustrated that extreme empathizers (Mean = 3.52; SD = 1.69) reported less control than systemizers (Mean = 5.69; SD = 2.72; p = .019) and extreme systemizers (Mean = 5.73; SD = 2.12; p = .026). It also revealed that individuals in the balanced brain (Mean = 4.20; SD = 1.68) category scored lower on *control* than systemizers (p = .010) and extreme systemizers (p = .025). A linear stepwise regression showed that the assigned condition (i.e., inclusion and exclusion) accounted for 40% of the variance (R^2 = .412) and that Standardized D score added 3.7% of the variance (R^2 = .448) in differences in the control need variable scores.

3.3.3. Real Players?

At the very end of the experiment participants were asked whether they believed that they were playing the game with "real" participants. Results

indicated that 78.2% of participants did not believe that they were playing the Cyberball game with "real" participants. Of those participants assigned to the exclusion condition, 86% (n = 58) said that they did not believe that the other participants were real players. Of those participants assigned to the inclusion condition 67.3% (n = 35) said they did not believe the other players were real. An ANOVA revealed that there was a significant difference between those who were excluded and included and belief in real players ($F(1,118) = 6.606, p = .001$). Participants who were excluded were less likely to believe that they were playing with real players whereas participants that were included were more likely to believe state that they believed their opponents were real players compared to the excluded participants.

3.4. Discussion

Findings show that social exclusion resulted in a significant difference in self-reported levels of three out of four hypothesized fundamental needs (*belonging*, *control*, and *self-esteem, but not meaningful existence*) and the mean supplementary variable (*anger* (reverse scored), and *enjoyment of the Cyberball game*). It is important to note, that while supporting literature suggests that the difference between the inclusion and exclusion groups on the fundamental needs is due to a decrease in the four fundamental needs on the part of the excluded participants, one cannot say without a doubt that that is the case. There is no pre-experimental questionnaire for comparison to indicate that the change is definitely in the directions that I am suggesting. However, while it is possible, it is unlikely that the difference between the two groups is due to a significant increase in the fundamental needs on the part of the included participants and there was no change for the excluded participants. Herein, I interpret the results in support of the preceding literature, but I wanted to make it clear that my interpretation is *not* the only possible interpretation.

In addition, cognitive style affected participants' responses to the Cyberball game. Individuals with an empathizing and balanced cognitive style reported lowest levels of self-perceived control during the Cyberball game (regardless of inclusion or exclusion) and differed significantly from systemizers and extreme systemizers. Williams, Cheung, and Choi (2000) suggest that exclusion from the Cyberball game challenges participants' perceived control over the social interaction. Participants are unable to interact or influence the actions of the other players in an effort to regain inclusion. This results in a sense of loss of control. Perhaps empathizers report feeling less control, as they may be more sensitive to others' reactions and may be looking for ways to interact or influence the other players, but this is not possible in the game.

According to Baron-Cohen et al. (2003) empathetic individuals put themselves in "the other person's shoes" and are consistently sensitive to managing social interactions so that others are not hurt or offended. Empathizers are also able to effortlessly judge when someone else's emotions have changed and to infer why their emotions have changed and what might make them feel better. Therefore, when empathizers realize that they cannot influence the other players in the game, it seems to result in lower levels of self-perceived control. While exclusion accounts for the majority of variance in the four fundamental needs, cognitive style accounts for additional variance for the *Control* need variable. In other words, my findings suggest that empathizers have different needs than systemizers in social interactions, particularly in relationship to controlling what occurs in that interaction. Thus, knowing individual differences in cognitive style adds to the understanding of the impacts of social exclusion on individuals.

Furthermore, despite the fact that 78.2% of participants reported that they did not believe that they were playing the game with "real" participants my findings showed that individuals were still sensitive to social exclusion in a

virtual environment. Regardless of whether the participants believed that the other players were real, the results bear out my prediction that exclusion from the game would have self-reported negative effects, and are consistent with earlier findings (Smith and Williams, 2004; Williams et al., 2000; Zadro et al., 2004). Zadro et al. (2004) discovered that being excluded during the Cyberball game was painful regardless of whether the exclusion came from a computer or a human being. This supports the notion that social exclusion has a profound effect on individuals. Human beings' sensitivity to social exclusion in fact appears to trump the realization that one is being excluded by a computer program. It should be noted, however, that I was unable to veryify the participants' reports that they did not believe they were playing against human opponents. Understanding more about that small percentage who believed the opponents were real would be interesting. Given the basic descriptive and inferential statistics that I ran on this variable, results suggest that excluded participants reported believing that participants were not real more often than the included participants. This is interesting to consider. Out of pure conjecture, one might speculate that exlcuded participants claimed that they believed that the participants were not real as some sort of protective mechanism to make themselves feel better about being excluded. They can then justify to themselves that the game excluded them, as it was programmed to do, not the other participants as they were led to believe. As discussed above, participants still react negatively to exclusion regardless of the source (computer versus human), but perhaps excluded participants were able to make themselves feel better after the fact by recognizing that the other participants were not real.

Zadro et al. (2004) suggest that because ostracism from a group carries such negative consequences, such as loss of contact with significant others, loss of resources, and possibly death, that human beings have evolved a sophisticated set of mechanisms for detecting exclusion and ostracism.

These mechanisms for detecting exclusion prompts emotional responses which motivate individuals to react and respond in ways aimed toward regaining inclusion into the group or cope with exclusion. My findings suggest that the degree to which these emotional responses are mobilized may be partially dependent on cognitive style.

The study is limited in several respects. First, because the study was conducted via the internet, the conditions of participation, including who took part in the study, were out of my control. Information about participants' state (e.g., tired) or the conditions (e.g., location) under which they completed the study is not available. While it is unlikely, this may have impacted the results. However, I was able to track participation time and network location (i.e. IP address) which allowed me to control for multiple participation. Second, the Cyberball game is a Java program which runs in an internet browser. Some potential participants were unable to complete the game because they had difficulty loading the game or did not have Java installed. In an effort to avoid this, I added a link at the beginning of the game where participants could download and install Java. Third, studies (Kraut et al., 1998; Williams et al., 2000) suggest that individuals who spend time on the internet pursuing social interactions, may be more susceptible to depression and loneliness. Kraut et al. (1998) discovered that spending time on the internet may replace face-to-face relationships and interactions with weaker and more superficial internet relationships. This may result in a decreased sense of belonging for high-frequency internet users. Since the participants in this study volunteered to take part in an interactive online game, they may be more likely to pursue social relationships over the internet, and may be more likely to suffer from depression and loneliness. Thus, this may be the population to which this data can be generalized. In future studies, I plan to include the Rejection Sensitivity Questionnaire (Downey and Feldman, 1996) to assess sensitivity to rejection. Finally, the gender imbalance might be

problematic. More females than males took part in the study. The imbalanced sex ratio could have impacted the results, since I was examining empathizing and systemizing which has been closely linked to sex in the past (Baron-Cohen, 2003). I realise that it would be best to have included equal numbers of males and females in each brain category (empathizing, systemizing, etc.). I was unable to do that in this study, but think that it would be an excellent sampling strategy to implicate in a replication of the study.

In conclusion, a high empathizing cognitive style is associated with decreased feeling of control during the Cyberball game. This study adds information for Williams' ostracism model suggesting that cognitive style impacts the fundamental need for control, thus acting in a mediating or moderating capacity. In future research, it would be interesting to apply this investigation to the *Reactions* module of Williams' model. For instance, although the fundamental needs were only minimally different due to brain-type, perhaps immediate and short-term reactions would be impacted. There is a lengthy literature accounting for aggression as a result of exclusion (Twenge, 2000; Leary et al., 2003; Bingham, 2000; Crook, 1997; Lemonick, 2002) . Investigating the relationship between reaction to exclusion and cognitive perspective might advance the understanding of *who* is likely to turn to aggression as a result of social exclusion. Because there seems to be a connection between brain type and gender (Baron-Cohen, 2003), and there are gender differences in aggressive behaviour (Bennett, Farrington, and Huesmann, 2005), perhaps a systemizing brain type (tradionally male brain type) would predict a more aggressive response following social exclusion. Additionally, it would also be interesting to examine the neural correlates of social exclusion and cognitive style to see if there are differences in the neurological response to social exclusion dependant on cognitive style.

Chapter 4 Cognitive Bias Associated with Threat-Related Information Pertaining to Social Exclusion

4.1. Introduction

Primates, and especially humans, have remarkably large brains for their body size (Aeillo and Wheeler, 1995; McHenry, 1994; Ruff et al., 1997). However, these large brains do not come without a cost. The brain is very metabolically costly for its size and weight, using approximately 20% of the body's energy (Aiello and Wheeler, 1995). Additionally, the significant weight of the human head makes the neck more susceptible to breakage, and the girth of the head makes childbirth more difficult for women. Evolutionary theorists believe that the costs associated with increased brain size and metabolic rate are outweighed by the adaptive benefits that are endowed to organisms with large, encephalized brains (Aiello and Dunbar, 1993; Byrne and Whiten, 1988; cf. Clutton-Brock and Harvey, 1980). The large modern human brain is very sophisticated and allows for abstract thinking, reasoning, learning, scenario building (Geary, 2009; Stone, 2006), and mentalizing about others mental states (Premack and Woodruff, 1978; Frith and Frith, 1999; Dunbar, 1998). It is hypothesized that the environment our hominid ancestors faced forced brain evolution along this path to solve adaptive and social problems in the social domain (Aiello and Wheeler, 1995).

The Ecological-Dominance-Social-Competition Hypothesis (EDSC) (Alexander, 1989; Geary, 2009; Flinn, Geary, Ward, 2005 for a complete review) claims that human dominance over ecological challenges like the weather and earthly elements allowed for the development of a novel set of selection pressures, which appeared in the form of competition from other humans. As selective pressures changed, social intelligence became essential for survival and was selected for. Social group living and interaction requires social intelligence in order to detect deception, punish

cheaters, form coalitions, and to abide by social hierarchical rules and regulations. This model presents a framework for thinking about the evolution and development of intelligence as well as incorporating the key features of the ecological and climatic models of brain development (Ash and Gallup, 2008; Geary, 2009). However the EDSC does not explain why only primates would require the larger brain when other animals were exposed to the same climatic and ecological pressures. The Social Brain Hypothesis (Dunbar, 1992) also referred to in the past as Machiavellian Intelligence hypothesis (Byrne and Whiten, 1988) offers an alternative perspective on the development of intelligence. The crux of these hypotheses rests upon neocortical development and its importance in social intelligence. The large increase in neocortex size (which sets humans and primates apart from other animals) is thought to be responsible for their uncanny ability to navigate and operate successfully in a social environment. Research shows that neocortical size is correlated with social group size (Dunbar, 1992), the size of grooming cliques (Kudo and Dunbar, 2001), social strategies employed in mating contexts (Pawlowski et al., 1998), and frequency of social play (Lewis, 2001). Together these findings point toward the conclusion that brain size impacts the number of social relationships an organism is capable of maintaining. Indeed, the social brain hypothesis argues that the large neocortex found in the human brain evolved to assist with human and primate social intelligence and interaction (Dunbar, 1992).

Despite the disputes on what events spurred the development of greater intelligence, both general and social in nature, the anatomical data supports the theory that the primate brain is larger, and it is because of this large size that primates have special cognitive abilities that are not shared with other mammals (Aiello and Wheeler, 1995; McHenry, 1994, Ruff et al., 1997). Given this scheme of evolutionary neurocognitive development, characteristics of intelligence that are innate to the human species are those

that are closely embedded with successful group living and sociality such as cooperation, observance/obeying of social rules, group loyalty, and avoidance of social exclusion (Brewer, 2004).

4.1.1. Group Membership and the Cognitive Impact of Social Exclusion

Intelligence and social structure are two of the most significant adaptations unique to the human species (Baumeister, et al., 2002). Since social living has been a large part of human evolution, and humans are equipped with a complex neuroanatomy allowing for enhanced socialization skills, it is not surprising that a great deal of human attention is focused on maintaining social interactions (e.g. theory of mind and intentionality). Living in a group provides many benefits for human beings, and being accepted as a member of a group is presumed to be adaptive, from a good design perspective, because it provides protection, food sharing, access to resources, access to shared information and knowledge, and access to mating resources, all of which are essential to survival (Baumeister et al., 2002). When survival is at stake expulsion from a group is something that is very serious and could have dire consequences for the expelled. Therefore, one might hypothesize that when one is excluded from the group he would benefit from focusing all of his intellectual resources toward reinclusion, which might result in regaining some of the benefits associated with group living (e.g., survival; Baumeister et al., 2002). However, it is possible that intelligence is designed to facilitate social interaction (e.g. Social Brain Hypothesis), not to stand in as a substitute for group membership. According to this line of reasoning, an individual who is excluded would have a lesser need for intelligence because he is no longer working to navigate the complex social environment of group membership/inclusion, nor is he engaged in cooperative interaction where such intelligence is necessary (Baumeister et al., 2002).

A review of the literature reveals that exclusion is in fact related to impaired performance on intelligence tests as well as impaired memory (Baumeister et al., 2002). In a series of studies, Baumeister and colleagues (2002) conducted the aforementioned study when they were stumped by the incongruity in behavioural responses to social exclusion. For instance results revealed that social exclusion triggered aggression (Twenge, Baumeister, Tice, and Stuck, 2001), decreased prosocial behaviour (Twenge et al., 2007), and increased self-defeating behaviour (Twenge, Catanese, and Baumeister, 2002), but it produced relatively little emotional change (cf. Williams et al., 2002; Zadro et al., 2004). Because there was no consistent explanation for these findings, Baumeister et al. (2002) began to think that cognition might be acting as a mediating variable. Before continuing on it is important to mention that intelligence, as it is referred to herein, is a measurement of intelligence as a trait (Horn, 1972) and the short-term impact of exclusion on cognitive processes (e.g. intelligent thought) is being discussed.

4.1.2. Cognitive Processing and Exclusion

As mentioned previously (refer to Section 4.1.1.) Baumeister et al. (2002) reported that participants exhibited cognitive decrements on intelligence tests after they were informed that they would most likely end up alone in life (i.e. excluded). Participants in the life alone condition showed the largest decrements in performance on an intelligence test when answering questions that required recalling information from a difficult passage and on a test of logic and reasoning. However, performance was unaffected when participants had to answer questions regarding a noncomplex passage and performing a rote-memory task. When excluded participants were debriefed about the experiment prior to attempting the information recall, they were significantly better at recalling the information which suggests that they were able to encode the information but unable to

retrieve it in the exclusion condition. The threat of social exclusion reduced individual's capacity for "intelligent thought" during the study. The authors propose that intelligence is a key part of social group membership (social inclusion) and when that is threatened individuals suffer a reduced capacity for cognitive processing.

Cognitive processes, dependent on executive control, seem to be impacted by social exclusion (Baumeister and DeWall, 2005). It has been found that self-regulation is also negatively impacted by exclusion (Baumeister, DeWall, Ciaracco, and Twenge, 2005). Baumeister et al. (2005) discovered that self-regulation decreased when people were subjected to exclusion. In one instance participants were given one of three scenarios: future alone, control, and future belongingness (see Chapter 2, Section 2.1. for a review of this paradigm). In the future alone (exclusion) condition, participants drank less of a bad tasting health drink than individuals assigned to the other conditions. Furthermore, participants who were informed that they were not selected to join a group (excluded) showed impaired self-regulation in a cookie taste test. Rejected participants in the first study were unable to make themselves imbibe a substantial amount of a healthy drink, even though they were fully aware of the health benefits. In the second study excluded participants ate significantly more cookies than those in the other control and belongingness conditions. Results were interpreted as evidence that individuals who were faced with exclusion had an inhibited ability to self-regulate, possibly because of an impact in cognitive or executive function. In a study by Pickett, Gardner, and Knowles (2004), participants were given a Vocal Emotional Stroop Test where they were asked to determine the voice tone (positive or negative) of words. In one condition the words are incongruent with the voice tone (negative tone + positive word; positive tone + negative word) and in the other condition the words were congruent with the tone (positive tone + positive word; negative tone + negative word). Participants with an increased need to

belong and those in the rejection condition showed latency in the positive incongruent category. Pickett and colleagues (2004) argue that this result indicates that participants are showing an attentional bias towards positive words, not just negative words; therefore they are attuned to both positive and negative cues "indicating both potential acceptance and rejection" (p. 1105). This seems to be an adaptive strategy, which allows individuals to focus on salient cues that may be essential to changing their inclusionary status as well as maintaining group membership.

4.1.3. Attentional Bias

Individuals with clinically diagnosed anxiety as well as those with normally aroused anxiety demonstrate attentional biases towards threat-related information (Jansson, Lundh, and Oldenburg, 2005). The relationship between anxiety and cognitive bias for threat-related information has been well established in the literature. For instance, individuals with clinically diagnosed anxiety show attentional bias to threat-related information stimuli (Yovel and Mineka, 2004; Mineka, Rafaeli-Mor and Yovel, 2002; Williams, Watts, MacLeod, and Matthews, 1997). As an example of a non-clinical study which shows this same pattern, Thomson, Patel, Platek, and Shackelford (2007) discovered that when participants were primed with a sexual infidelity scenario their response time in processing words related to infidelity were significantly slower than their response time to neutral words. Thus when individuals were primed with a negative scenario that had some self-relevant importance (which increased anxiety), they tended to show an attentional bias to stimuli relating to information about that negative scenario. Williams, Mathews, and MacLeod (1996), suggest two strategies for assessing attentional bias: the emotional Stroop task and testing audio and visual thresholds; herein I will focus on the former.

The original version of the Stroop test (Stroop, 1935) has been in use for many decades. The Stroop effect shows that individuals experience a delay in colour naming of a word when the word also relates to a colour. For instance, one is asked to say the colour of the word BLUE, but the word is printed in green. Individuals show a marked interference in processing. McKenna and Sharma (2004) argue that the traditional Stroop test (Stroop effect) is the effect of "contrast of incongruent stimuli" (p. 382). In the case of the emotional Stroop test the effect is such that the response time slows as the emotional significance of the stimuli increases. In the emotional Stroop task, emotionally valenced words are presented to the participant and they are asked to say the colour of the ink of that word. Words that are negatively emotionally charged (e.g. evil) usually cause a delay in response time compared to words that are neutral (e.g. ocean). It is important to note that it has been suggested that it is erroneous to refer to the task as an emotional version of the Stroop task (McKenna and Sharma, 2004) because it is not actually a Stroop test; however, I will use the refer to the task as the emotional Stroop because for all intents and purposes that is the recognized name of the task. The emotional Stroop test is relevant to this study, and it shows how attentional bias to emotionally relevant stimuli can slow response time, indicating a possible impairment in one's processing of information (Williams et al., 1996).

4.1.4. Rejection Sensitivity

Individual differences in the need to belong can impact a person's sensitivity to their social environment and interactions. For instance, one's need to belong is highly correlated with a successful ability to decode social cues and increased attention to vocal tone, among other things (Pickett et al., 2004). However, humans cannot possibly attend to all of the social information in the environment at once; therefore, people tend to seek out evidence that reinforces what they already believe is true

(Cacioppo and Hawkley, 2005). In many ways individuals often create self-fulfilling prophecies for themselves. For example, if individuals have a high self-esteem and believe that other people will like them, then those individuals tend to act in a more open and friendly manner drawing people to them, thus, appearing more likeable and popular, and boosting their self-esteem. On the other hand, lonesome individuals tend to have an increased negative evaluation of the world and social interactions, which only works to increase their feelings of loneliness and isolation (Duck et al., 1994). The same is true of rejection. Individuals who are sensitive to rejection have increased anxiety about the possibility of being rejected and the likelihood of being rejected (Cacioppo and Hawkley, 2005).

4.1.5. Aims and Hypotheses

The aim of this study was to use an emotional Stroop task to investigate the effect that social exclusion had upon cognitive processing. This experiment was designed to test the *Reactions* module of Williams' ostracism model (1997; See Chapter 1, Section 1.7. for a review). It was hypothesized that when participants experienced an episode of ostracism from a group and were then presented with words relating to ostracism (as well as other emotional and control words) participants would demonstrate inhibited cognitive processing and have a delayed response time to the specific word class. Second, I hypothesized that individuals who scored high on rejection sensitivity would report higher levels of distress as a result of being excluded and would demonstrate a slower response time to words in the exclusion class on the emotional Stroop task.

4.2. Methods

4.2.1. Participants

The participants were 20 people from the University of Liverpool (10 males and 10 females, $M_{age} = 28$, $SD_{age} = 10.09$)[1]. Participants were all asked to sign a consent form before taking part in the study. Permission to run the study was granted by the School of Biological Sciences Committee for Research Ethics at the University of Liverpool. Participants were recruited through the university announcement system.

4.2.2. Rejection Sensitivity Questionnaire

All participants completed the Adult Rejection Sensitivity Questionnaire (Downey, Berenson, and Kang, 2006; Downey and Feldman, 1996) for adults. The Adult Rejection Sensitivity Questionnaire (A-RSQ) contains 9 questions (each with two parts: a and b) pertaining to rejection concern and acceptance expectancy. Participants were presented with a statement at the beginning of each question and then answered the questions based on their reaction to that statement. For instance, the statement says, "You ask your parents or another family member for a loan to help you through a difficult financial time." The rejection concern question reads as follows: "How concerned or anxious would you be over whether or not your family would want to help you?" Participants rated their concern on a scale from 1 to 6

[1] It is important to mention that while 44 individuals took part in the study, only 20 people are included in the analysis of data. I programmed the Cyberball game to randomly assign participants to an inclusion or exclusion condition; however an error occurred and the program/software only excluded a fraction of the participants. Overall, the excluded participants were significantly fewer (n = 10) than the number in the included condition (n = 34). In order to compare the two groups, I randomly selected 10 participants from the inclusion condition for comparison to the 10 in the exclusion condition.

(1 = *very unconcerned* and 6 = *very concerned*). The acceptance expectancy question states, "I would expect that they would help me as much as they can." Participants then rated their level of agreement with that statement on a scale from 1 to 6 (1= *very unlikely* and 6 = *very likely*). Questions relating to acceptance expectancy (part b) have to be reverse scored (7 - acceptance expectancy). Rejection concern score and the reverse-scored acceptance expectancy score is multiplied together to create a score for each question. The mean of the resulting nine scores is taken to find the overall rejection sensitivity score.

4.2.3. Cyberball

After the A-RSQ was completed, participants played Cyberball on the computer. All participants were told that they were playing with other participants over the internet. Participants were randomly assigned to the inclusion or exclusion condition. Participants in the inclusion condition tossed the ball back and forth with the two other "players" for the entirety of the game. Participants in the exclusion condition received the ball on an average of 6 times and then were no longer included in the game. For the remainder of the game they watched the other two "players" toss the ball amongst themselves.

4.2.4. Emotional Stroop Test

Immediately following the end of the game participants completed the emotional Stroop task. The emotional Stroop test is designed to investigate neutral versus anxiety provoking words. A slower response to words in the anxiety provoking class, or in this case an exclusion class of words, is interpreted as an attentional bias or interference in attention due to some emotional self-relevance or valence of the word (Teachman, Smith-Janik, and Saporito, 2007; Thomson, Patel, Platek, and Shackelford, 2007). Participants were presented with twenty-five words that were each

presented four times. There were five categories of words and each category contained 5 words. The categories included the following: inclusion, exclusion, neutral, positive emotional, and negative emotional. The neutral, positive, and negative words were taken from McKenna and Sharma (2004). The words included in these classes were GLORIOUS, HAPPY, LOVE, PEACE, PLEASURE, AGONY, AWFUL, EVIL, FAILURE, TERRIBLE, HILL, LEAVES, OCEAN, ROAD, TUNNEL. Since there was not a pre-existing list of words for the inclusion and exclusion class, I selected a list of twenty words for each category and had a group of 30 individuals rate the words for their relationship to each class (1 = *closest to inclusion or exclusion* to 5 = *not pertaining to inclusion or exclusion*). The top five words with means closest to 1 were used in the study. These words include the following: ACCEPT, BELONG, GROUP, INCLUDE, BANISH, EXCLUDE, IGNORE, OSTRACISE, REJECT. The word TOGETHER was also selected to be included in the study; however because of a typo the word was excluded from the results. I was afraid that the typo would interfere with participants' processing of that word and their response time. Each word was presented four times in a random order. The emotional Stroop task was presented using PX-Lab (http://www.pxlab.de) (Irtel, H., 2007) on a HP Laptop with a 15 inch screen and a standing microphone was used to record their responses. Participants were given instructions verbally as well as on the screen. They were presented with a word on the screen, but instead of reading the word, they named the colour of the word. For instance, if "HAPPY" appeared on the screen in red ink, the participant was instructed to say "red" into the microphone. The microphone recorded the responses and the computer recorded the time (response time to begin an utterance) it took for participants to respond (name the colour of the word). Before analyzing the data the response times were converted to z-scores.

4.2.5. Post Game Questionnaire

Participants completed a questionnaire assessing their feelings associated with the Cyberball game. The post game questionnaire/fundamental needs questionnaire (Williams et al., 2000; Zadro et al., 2004) is designed to measure participants fundamental need states and level of distress following the game. The first portion of the questionnaire focuses on manipulation checks to ensure that participants in the exclusion condition recognized that they were excluded. The second portion of the measure assesses participants' levels of four basic needs: belonging, control, self-esteem, and meaningful existence. Mood is also measured. Responses were provided on a scale of 1 to 9 (1 = not at all and 9 = always). In some instances, the questions had to be reverse-scored so that the higher response would be equivalent to a more positive response.

4.2.6. Debriefing

Immediately following the completion of the experiment participants were debriefed. They were informed that the other players were fictitious and that they were playing Cyberball with the computer. Additionally, they were told that they were randomly assigned to inclusion and exclusion conditions. Participants were given the opportunity to ask questions about the study.

4.3. Results

4.3.1. Manipulation Checks and Post Game Questionnaire

Three manipulation checks were included in the questionnaire to assure that participants in the exclusion condition demonstrated that they were aware of the exclusion. Participants in the exclusion condition reported

feeling significantly less accepted, included, and more rejected compared to included participants (*F(1,19) = 53.85), p < .001;* See Table 4.1. for means). A Multivariate Analysis of Variance (MANOVA) revealed that participants in the exclusion condition reported significantly lower levels of the fundamental needs belonging and control (*Belonging, F(1,19) = 49.96, p < .001, partialη^2 = .720; Control, F(1,19) = 34.85, p < .001, partialη^2 = .659).* There was no significant impact on self-esteem and meaningful existence. Two additional questions were included at the end of the post game questionnaire: "I felt angry during the Cyberball game," and "I enjoyed playing the Cyberball game." I combined the variables and calculated a mean response An ANOVA revealed that participants in the exclusion condition felt more angry during the Cyberball game and experienced significantly less enjoyment than participants in the inclusion condition (*F(1,19) = 17.99, p < .001*). There was no effect for mood.

Fundamental Needs[a]	Mean Exclude Condition	Standard Deviation Exclude	Mean Include Condition	Standard Deviation Include
Belonging	3.133	1.079	6.667	1.155
Control	3.400	1.215	6.400	1.052
Self-esteem	5.800	1.450	7.100	1.343
Meaningful Existence	4.867	0.740	5.233	0.876

Table 4.1. Means and Standard Devaitions of Variable Scores. Scores range between '1 = not at all' to '9 = not very much'; some items are reverse scored. [a]Each of the fundamental need scores represents an average of three questions from that category.

4.3.2. Response Time on the Emotional Stroop Test

Participants in the exclusion condition responded significantly slower to a majority of the words on the emotional Stroop test (See Table 4.2 for mean response times). However, results of the MANOVA indicated that participants were slower on all classes of the emotional Stroop test with the exception of the inclusion word category (Exclusion: *(F(1,19) = 4.492, p = .048, partial* $\acute{\eta}^2$ *= .200)*; Positive emotional: *(F(1,19) = 5.695, p = .028, partial* $\acute{\eta}^2$ *= .240)*; Negative Emotional: *(F(1,19) = 4.771, p = .042, partial* $\acute{\eta}^2$ *= .210)*; Neutral: *(F(1,19) = 5.114, p = .036, partial* $\acute{\eta}^2$ *= .221)*; Include: *(ns: F(1,19) = 3.804, p = .067, partial* $\acute{\eta}^2$ *= .174)* See Table 4.1.). An ANOVA was used to test the relationship between the number of correclty named words and inclusion and exclusion condition. Results indicated that there was no significant difference ($p > .05$) between the two groups and their ability to say the color of the words without error.

Word Class	Mean (z-scores)	Standard Deviation	Standard Error
Exclusion Words			
Exclusion	0.724	1.696	0.537
Inclusion	-0.457	0.475	0.150
Positive Emotional			
Exclusion	0.842	1.673	0.529
Inclusion	-0.467	0.455	0.149
Negative Emotional			
Exclusion	0.734	1.673	0.529
Inclusion	-0.466	0.471	0.149
Neutral			
Exclusion	0.740	1.603	0.507
Inclusion	-0.474	0.558	0.176
Inclusion Words			
Exclusion	0.770	1.785	0.564
Inclusion	-0.366	0.456	0.144

Table 4.2. Mean, Standard Deviation, and Standard Error of Response Time to Word Class. Response times have been converted to z-scores. Mean z-scores are shown above.

4.3.3. Rejection Sensitivity Questionnaire

The Rejection Sensitivity Questionnaire did not correlate with the responses on the post game questionnaire or with the participants response times on the emotional Stroop Test.

4.3.4. Response Time and Fundamental Need

A regression equation predicted that a decrease in the fundamental need of control accounts for 21% (R = .455; R square = .207; b = -.325, p = .044) of the variance in response time across both the inclusion and exclusion groups. A decrease in feeling of belonging did not account for any variance in response time.

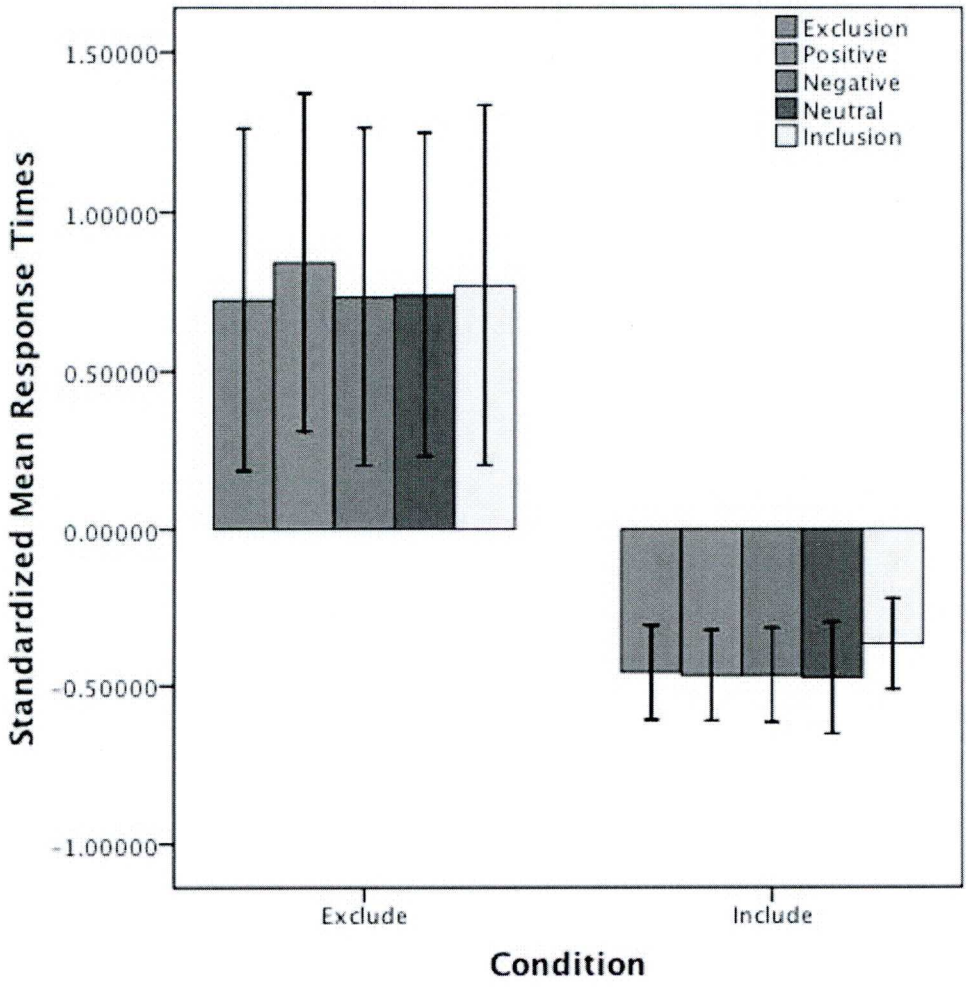


Figure 4.1. Mean Response Times (z-scores) for Word Class and Inclusion and Exclusion Condition. Excluded participants showed significantly latent response times compared to included participants on all word classes, with the exception of the inclusion word class.

4.4. Discussion

Participants in the exclusion condition reported lower levels of two of the four fundamental needs. These results partially replicate findings reported in Chapter 3. Excluded participants indicated they felt a lower level of belonging and control when excluded from the Cyberball game. However, self-esteem and meaningful existence were not impacted. Most importantly, there was a significant difference between the two groups in response time on the emotional Stroop; these differences can be attributed to feelings of loss of control, and possibly belonging; as the loss of control accounted for 21% variance in latent response time. There was no effect for rejection sensitivity on the four fundamental needs or on response time in the emotional Stroop.

Indeed, the results indicate that being excluded caused participants to show a delay in their response to words on an emotional Stroop task. Previous studies have shown that there is impairment in intellectual functioning where participants in the exclusion condition were unable to complete as many questions on an intelligence test as participants in the inclusion condition (Baumeister et al., 2002). However, my study was designed to test whether or not participants would have a slower reaction to certain types of stimuli, particularly exclusion-related stimuli. I hypothesized that participants in the exclusion condition would show an attentional bias to words specifically associated with exclusion. However that was not the case. It appears that the latency occurs for almost all word classes. That is, excluded participants were significantly slower in providing their responses for all word classes (exclusion, positive, negative, and neutral)

except for the inclusion word class. There was a trend towards significance for this word class, as well. It is possible that if the sample size had been greater than 10 for each group, there might have been a significant difference in response time for this word class as well; however that is purely conjecture and there is no evidence to accompany it. While the findings are not in accordance with my hypothesis they are not beyond explanation. If excluded participants had only showed latency to the exclusion word class this would have shed some light on the cognitive processes that are impacted by exclusion. It would suggest that focus, attention and sensitivity are directed towards exclusion, as is common with people with anxiety and panic disorder focusing attention to threat and fear, and possibly suggest that anxiety is a key underlying component in fear of social exclusion. Individuals with anxiety and panic disorder show latency in response to words relating to anxiety and panic. In the current study, participants showed a general attentional decrement in latency, which can't be described as a specific attentional bias because they showed latency for all words. The results indicated that regardless of the emotional content or meaning of the word, participants in the exclusion condition were significantly delayed in their response time. Exclusion does not only diminish the fundamental needs of control and belonging, but it also impacts an individual's ability to complete a word-naming task (emotional Stroop). Thus, it seems that cognitive processing, generally, is delayed by exclusion and particularly the loss of the feeling of control. If the results had shown that participants were sensitive to the kind of word stimuli and showed bias in reaction time to words associated with exclusion, it might have indicated that there was an emotional bias to increased sensitivity to rejection information. However, that was not the case in this sample.
There were several additional limitations to this study. First, the between groups could seen as a limitation. An alternative, within groups design could have tested people on the emotional Stroop before and after

exclusion, and thus allowed for the examination of latency differences as a function of treatment. However, I do not feel, nor does the literature suggest (Baumeister et al., 2002; Pickett et al., 2004) that this sort of design would have revealed something about the effect of social exclusion because it would have been flawed with priming the participants with the emotional Stroop producing the possibility of practice effects. Perhaps incorporating a control group that did not play the Cyberball game but just took the emotional Stroop would have been beneficial to the experimental design. The addition of a cognitive pre-test, to show that the difference on the emotional Stroop task was actually related to the experimental condition and not a general cognitive difference in the two groups would have been beneficial to the study. Had a measure of this sort been included then it would have been easier to argue that the conclusions drawn in this study are the most likely ones possible. However, since no such measure was used, I cannot claim that there is no other reason, despite its unlikelihood, that participants in the exclusion condition showed a delayed response time and reduction in cognitive processing. Additionally, it can be somewhat difficult to generalize from the emotional Stroop task to general cognitive function, so in the future use of a neutral task would help to bolster generalizations.

Second, a critical limitation is the sample size. A programming glitch caused the Cyberball program to assign 80% of the participants to the inclusion condition. Left with this imbalance in the sample I elected to use the 10 excluded participants and then randomly selected 10 included participants. A larger and more representative sample would have made the results more generalizable.

Overall, my interpretation of the results offer support to the hypothesis put forth by Baumeister et al., (2002). They argue that social exclusion impacts executive function and controlled processes. Therefore, when excluded participants were completing the emotional Stroop task their concentration

and focus was most likely interrupted by attempts to suppress emotional distress from exclusion (specifically decrease in feelings of control), resulting in latent response time. If participants had shown latency to a specific word class it might have indicated that a specific attentional bias to exclusion was at play; however participants were slower overall, regardless of word class. Participants were not more sensitive to exclusion cues after exclusion; they were slower completing the Stroop task because their focus was captured by attempts to suppress their emotional distress. In support of this interpretation, other studies (Eisenberger et al., 2003; Krill and Platek, 2009) have shown that in the anterior cingulate cortex (ACC) the distress response to social exclusion was mitigated by the right ventral prefrontal cortex (RVPFC). In other words, as activation in the RVPFC increased, activation in the ACC decreased. The ACC is known to be key neural substrate for social pain, and Eisenberger and colleagues (2003) suggested that the activation in the RVPFC mitigated the distress response. Increased activation in the ACC is correlated to increased distress, while increased activation in RVPFC is linked to decreased distress in social exclusion (Eisenberger et al., 2003). The RVPFC appeared to be regulating the distress response. Since this part of the brain is also involved in executive function and other important related tasks, it is possible that it was employed to diminish or inhibit distress, and was unable to attend to other tasks. This is where I think that brain imaging research may have implications for the findings in the present study. Excluded participants exhibited a delay in response time or impaired cognitive function and this may come as a result of parts of the brain being recruited to cope with distress as a result of exclusion. However, these conclusions cannot be fully supported by the data; they are only suggested by the data. Sternberg (1997) makes a good point about cognition and intelligence research: "Mental processes are always evaluated through behaviour of some kind. We draw conclusions about these processes from behaviour, but these conclusions are not always

justified. For example, poor performance on an intelligence test might reflect poor processing of information but also might reflect test anxiety, lack of motivation, inattention, or any number of other variables" (p. 1032). The aforementioned holds true for this study, while it is likely that the results are a reflection of the experimental conditions, it is impossible to rule out the other causes and factors of these behavioural outcomes, especially this instance since there was no pre-experimental assessment of cognition.

I began this chapter with a discussion of how intelligence evolved and how the evolution of intelligence may have a bearing on the decrease in intellectual function that is apparent after exclusion. My interpretation of the results, which is not the only interpretation possible, points towards an explanation suggesting that intelligence did not evolve to compensate for a loss of social group access (see also Baumeister et al., 2002). Instead, intelligence, or portions of cognitive processes associated with executive function, is incorporated in facilitating social interactions. After exclusion a portion of the cognitive processes is compromised, and this may occur in order to alert an individual, generally, to the exclusion. The exact nature of the interruption in cognition is unclear. The interruption could be attributed to distress or anxiety or any number of factors that can impact cognitive function.

The present findings add to Williams' ostracism model (1997; 2007), specifically to the *Reactions* module, by suggesting that one of the short-term responses to exclusion is stifled cognitive processing. Further research might investigate the long-term impact on cognition. Is this impact permanent until inclusion is regained, or does it pass after a terminal period of time? Additionally, further investigation into how participants are suppressing emotions, if in fact they are, would be enlightening.

Chapter 5 In-Group and Out-Group Membership and its Effects on Responses to Social Exclusion

5.1. Introduction

In this experiment, functional magnetic resonance imaging (fMRI) was employed to examine sensitivity to social exclusion in three conditions: same-race, other-race, and self-resembling faces.

5.1.1. Group Membership

People have a powerful need to belong in a social group and they spend a great deal of time developing and maintaining social relationships (Baumeister and Leary, 1995). Individuals tend to show inclusive preference for members of their own group (Allport, 1954; Brewer, 1999). A great deal of Social Psychological research has been conducted regarding group formation (Allport, 1954; Sumner, 1906; Sherif, 1966; Tajfel, 1981; Tajfel and Turner, 1986; Brewer, 1991; Brewer, 1999). These theorists focused on the development of individuals "ideas" regarding in-groups and out-groups and the involvement of cognitive processes in their development. Evolutionary psychologists trace the importance of group membership back to an "environment of scarcity" and it is suggested that individuals needed group support and alliance in order to compete with other groups for survival (Brewer, 1999). Furthermore, Brewer (1999) states, "In other words, as a species we have evolved to rely on cooperation rather than strength, and on social learning rather than instinct as basic adaptations" (p. 433). When group membership and social relationships are threatened by exclusion, people have a negative emotional response (Williams et al., 2000). Neural substrates involved in response to physical pain are also activated when a person is excluded or experiencing social pain (Coghill, McHaffie, and Yen, 2003; Eisenberger, Jarcho, Lieberman,

and Naliboff, 2006; Eisenberger and Lieberman, 2004; Eisenberger et al., 2003; Panksepp, 2005; Rainville, Duncan, Price, Carrier, and Bushnell, 1997). The dorsal anterior cingulate cortex (dACC) is one component of a more generalized pain matrix that is responsible for acting as a "neural alarm system" (Botvinick, Braver, Barch, Carter, and Cohen, 2001; Eisenberger and Lieberman, 2004; Ochsner et al., 2008) when one is experiencing physical or emotional pain. Specifically, the dACC is linked to the affective (but not the physical) distress response associated with pain (Rainville et al., 1997). Negative reactions to social pain, such as social exclusion, are pervasive. Research has demonstrated that the experience of exclusion is robust because the neural correlates of exclusion persisted even when participants observed a scenario that emulated exclusion (Eisenberger et al., 2003). This suggests that imagined exclusion evokes reactions similar to actual exclusion (Eisenberger and Lieberman, 2004; Eisenberger et al., 2003; Williams, 1997).

I conducted a functional magnetic resonance imaging study to examine how responses to social exclusion would be impacted by appearance of the excluder. Specifically, I investigated how level of resemblance to one's self, impacted activation associated with being excluded. Participants experienced exclusion in three conditions: same-race face, other-race face, and self-face resemblance. There were three main aims in this study. I am going to discuss each aim separately along with the background information that accompanies it.

5.1.2. Social Exclusion and Level Self-Resemblance

The first aim was to investigate how brain activation to exclusion would differ across the three conditions when playing Cyberball, a three-person ball toss game that can be programmed to exclude participants. I hypothesized that participants would show the greatest level of activation in the dorsal anterior cortex (dACC) when they were excluded during the

self-resemblance condition relative to the other conditions (self-resemblance > same-race > other-race). This hypothesis is guided by evidence suggesting that in humans, self-facial resemblance appears to act as a kin detection mechanism (Daly and Wilson, 1982; Platek, 2002; Platek, Critton, Burch, Frederick, Myers, and Gallup, 2003; Platek, Keenan, and Mohamed, 2005; Platek, Keenan, Gallup, Mohamed, 2004; Platek and Thomson, 2007). Self-resembling faces are perceived more favourably (Daly and Wilson, 1982; Platek, Keenan, Gallup, and Mohamed, 2004), rated as more trustworthy (DeBruine, 2002; Platek, Krill, and Wilson, 2009; Platek and Thomson, 2007) and more attractive (DeBruine, 2004) compared to non-self-resembling faces (see also (Platek, Krill, and Kemp, 2008). Self-face resemblance might unconsciously tap cues of kinship producing stronger feelings of cohesion with, and hence greater distress as a result of exclusion from, this group. Furthermore, Roberts, et al. (2005) discovered that unrelated but genetically similar individuals are rated more attractive, perhaps not only because of phenotypic similarity but also because of MHC similarity.

I also reasoned that there would be increased brain activation in the same-race condition as compared to the other-race condition because same-race faces represent in-group membership whereas other-race faces represent out-group membership (Platek et al., 2008). People respond differently to same-race faces relative to other-race faces (Cunningham et al., 2004; Eisenberger et al., 2005; Golby, Gabrieli, Chiao, and Eberhardt, 2001; Hart et al., 2000; Herrmann et al., 2007; Kim et al., 2006; Love, 2001; Meissner and Brigham, 2001; Phelps, 2000; Pinkham et al., 2008; Platek et al., 2008; Stahl, Kiefer, and Bukach, 2008; Tanaka, Kiefer, and Bukach, 2004). Because brain mechanisms can quickly categorize faces by race (Platek et al., 2008), this can be an important component of socially-based judgements, which are combined with in- and out-group facial stimuli. If the brain is able to quickly process faces, with respect to race or group

membership, then that information should be utilized when making decisions about behaviour during social interactions.

5.1.3. Fundamental Needs and Exclusion

The second aim of the study was to determine whether levels of self-reported distress as a result of being excluded correlated with the brain activation. Previous studies have shown a positive correlation with self-reported distress and dACC activation during social exclusion (Eisenberger et al., 2005; Eisenberger et al., 2003). Behavioural investigations of social exclusion have revealed that targets of exclusion report a decrease in satisfaction of four fundamental needs: belonging, self-esteem, control, and meaningful existence (Williams et al., 2000; Zadro et al., 2004). In accordance with my first hypothesis, I predicted that when participants were excluded in the self-resembling condition they would report greater distress relative to the other face conditions.

5.1.4. Implicit Bias

The final aim of the study was to test for a correlation between amygdala activation during exclusion and the effect of implicit racial bias (same-race v. other-race). People tend to show implicit racial bias in favour of their own race even if they explicitly express no bias for or against other race faces. For example, when participants are asked to categorize a same-race face as good, they are quick to do so. However, when asked to categorize an other-race face as good, they are considerably slower (Dasgupta, McGhee, Greenwald, and Banaji, 2000; Greenwald, McGhee and Schwartz, 1998; Phelps, 2000). I hypothesized that as implicit racial bias increased, activation would *decrease* in the ACC but *increase* in the amygdala. This would suggest that participants who are more racially biased were less distressed by exclusion in the other-race condition.

5.1.5. Application to Williams' Model

This experiment is concerned with two modules of Williams' ostracism model: the *Antecedents* and *Mediators or Moderator* modules (See Chapter 1, Section 1.7.). It applies to the *Antecedents* module as it manipulates physical characteristics of the source of exclusion, namely their race and degree of self-resemblance to the target. Indeed, the target's race also plays an important role and acts as a moderator as their impression of the excluder may be impacted by a shared race or different race.

5.2. Methods and Materials

5.2.1. Participants

Twelve Caucasian (*3* males; *9* females; $Mean_{age}$= *27.9*; $S.D._{age}$= 11.7) participants from the University of Liverpool volunteered for participation. Each participant provided written informed consent and the study was executed with approval from the university Committee of Research Ethics.

5.2.2. Stimuli Creation

Participants were digitally photographed under controlled lighting. Their image was then subjected to a morphing transformation using specialist software (Tiddeman et al., 2001). In order to create the average, morphed image, two-dimensional shapes of the participants' digital photographs were delineated at 179 points using specialist software (Tiddeman et al., 2001). Next the vector differences at each delineation point and an average face template were calculated, which provided a measure of how much each face differed from average. Images were then altered by 50% of the average face to create self-resembling images. Images were matched as best as possible for luminance and quality using Adobe PhotoShop CS2. Two self-resembling faces were made for each participant. Males and females were paired with and viewed same-sex partners for each condition

(Composite faces were created as follows: Base Male Face 1 + Male Participant's face = Male Self-resembling face 1; Base Male Face 2 + Male Participant's face = Male Self-resembling face 2; Base Female Face 1 + Female Participant's face = Female Self-resembling face 1; Base Female Face 2 + Female Participant's face = Female Self-resembling face 2). Same-race, and other-race faces were randomly selected from a freely available database and subjected to similar morphing procedure to retain stimulus consistency and appearance.

5.2.3. Imaging Procedure and Parameters

Participants were scanned using fMRI while they played seven rounds of the virtual ball toss game, Cyberball. Participants were scanned using a Siemens Symphony 1.5 Tesla scanner. Functional images were collected using an EPI sequence (TR = 3000 ms, TE = 45 ms, FOV 192x192mm, slice thickness = 3.5 mm, gap = .5, number of slices = 35). Participants also underwent a 7-minute structural scan (MPRAGE: 176 slices, TR = 1660 ms, TE = 3.04). Participants were given instructions on how to play Cyberball using an MRI compatible response pad (Current Designs, www.curdes.com) and told that during the scan they were going to be playing with two other players, via an Internet connection, located in computer labs at other locations on the university campus (Williams et al., 2000). In actuality the other two players were computerized confederates programmed by the investigators.

In the first three rounds participants played Cyberball with the same-race, other-race, and self-resembling groups (condition order was randomized across participants), and these three rounds were all inclusion rounds. In the three following rounds (rounds 4-6), the same players excluded participants (order also randomized). For the exclusion conditions, the game began as it did in the first three rounds, but as time passed (~30 seconds), the other players stopped tossing the ball to the participant. The

data were pre-processed (Jenkinson and Smith, 2002; Smith 2002) and analyzed using the FMRIB Software Library (www.fmrib.ox.ac.uk/fsl) (Smith et al., 2004). Statistical thresholds were cluster corrected and the z-score of the cluster was greater than or equal to 2.3, $p < .05$ (unless otherwise stated). What are reported within is the peak activation voxels within the clusters.

5.3. Results

5.3.1. Effect of Exclusion as a Function of Facial Resemblance

Results indicated that activation in the anterior cingulate cortex (ACC) was highest during the self-resembling and same-race exclusion rounds of the game. I tested the hypothesis that participants would show the greatest level of activation in the dorsal anterior cortex (dACC) when they were excluded (compared to inclusion) during the self-resemblance condition relative to the other conditions (self-resemblance > same-race > other-race). This contrast revealed activation in several areas of the ACC (MNI coordinates: z = 3.64, -2, 46, 12; z = 3.31, 6, 44, 2; z = 3.85, 16, 20, 34). To further investigate the nature of this relationship an ROI was computed in the ACC and discovered a non-linear (quadratic) relationship that revealed that the ACC was most active to self-resembling and same-race faces relative to other-race faces during exclusion (See 5.1.).

5.3.2. Effects of Self-Reported Needs

It was anticipated that participants' self-reported fundamental needs would be affected in the exclusion conditions. In particular, I hypothesized that participants would report a decrease in four fundamental needs as a result of exclusion in the self-resembling condition and that there would be a corresponding increase in ACC activation. I anticipated that activation in the ACC would follow a linear pattern of self-resemblance > same-race >

other-race; instead, results showed a quadratic model was the best fit. Participants exhibited the greatest ACC activation in conjunction with the self-reported distress or impact on fundamental needs when they were excluded in the same-race relative to the other-race and self-resemblance conditions (anterior cingulate gyrus z = 3.5, -6, 28, 24; posterior cingulate z = 3.49, -4, 64, 20). A correlation between ACC activation and mean *needs* revealed that in the same race condition activation in the ACC showed a significant negative correlation with mean *needs* ($r(11) = -0.734$, $p = 0.01$) (Figure 5.1.). In other words, the less impact that a person felt on their sense of belonging, control, self-esteem, and meaningful existence the less the ACC was activated.

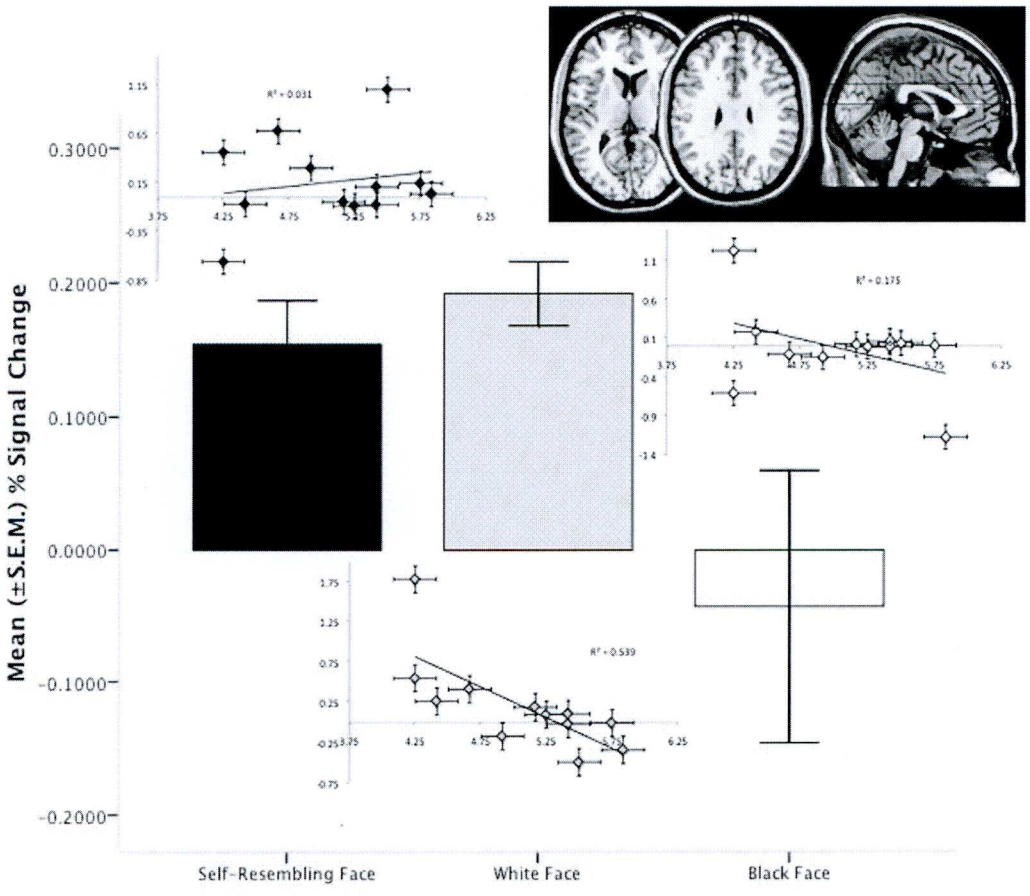


Figure 5.1. ACC Activation to Exclusion in the Three Conditions.

a) Mean (±S.E.M) percent signal change and statistical parametric maps for activation in ACC in response to self-resembling condition (black bars), same-

race condition (gray bars), and other-race condition (white bars) during exclusion round. b) Inlaid plots show the correlation between ACC activation and mean *needs*. Only the same-race condition (gray diamonds) showed a significant negative correlation with mean *needs* ($r(11) = -0.734, p = 0.01$) (Inlaid plots: black diamonds = self-resembling condition; grey diamonds = same-race condition; white diamonds = other-race condition).

Previous investigations have observed activity in the right ventral prefrontal cortex (RVPFC) during social exclusion (Eisenberger et al., 2003). In this study the correlations between mean *needs* and percent signal change for ROI's localized to the left and right VPFC (ventral prefrontal cortex – also called the OFC). There was a trend toward decreased activation in RVPFC to other-race faces ($r(11) = -0.407, p > .05$) and a significant decrease in LVPFC to other-race faces ($r(11) = -0.604, p < .05$) (See Figure 5.2.). Additionally, I correlated ACC activation with right and left VPFC activation because activation in these two areas has been shown to have a negative correlation. Results showed an increase in RVPFC activation as activation in the ACC decreased. This suggests that activation of the RVPFC mitigates the distress response that is activated in the ACC. However, the results revealed that activation in the ACC was positively correlated with activation in the left ($r = .841$; $p = .001$) and right VPFC ($r = .697$; $p < .05$) in the other-race exclusion condition only.

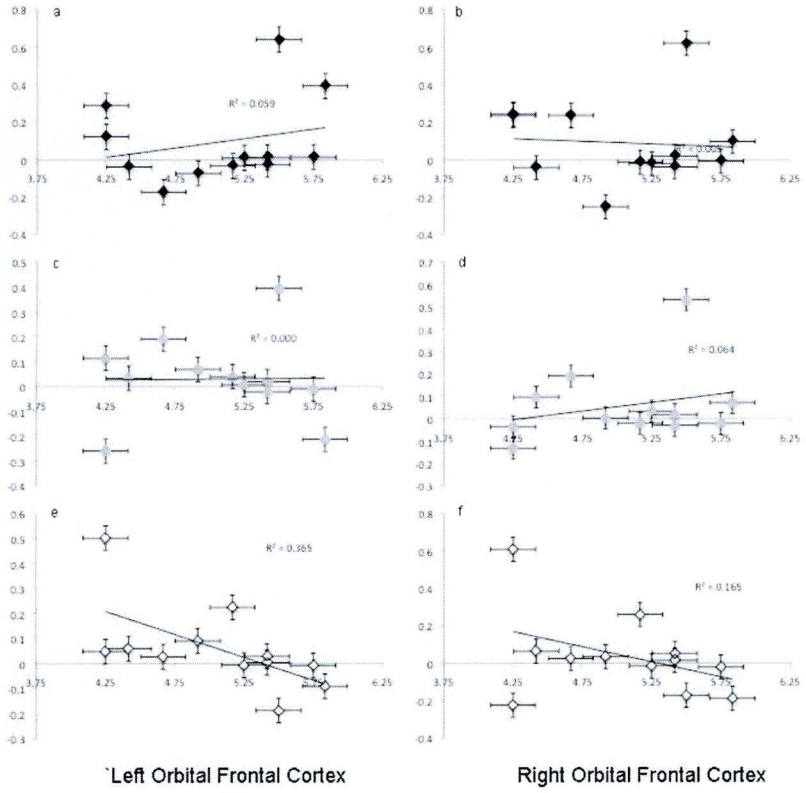


Figure 5.2. Ventral Prefrontal Cortex Correlation With Mean Needs.

Correlations between mean *needs* and percent signal change across subjects for ROI's localized to the left and right ventral prefrontal cortex (VPFC). There was a trend for a decrease in right VPFC activation to other-race faces and a significant decrease in left VPFC to other-race faces (black diamonds = self-resembling condition; gray diamonds = same-race condition; white diamonds = other-race condition.)

5.3.3 Effect of Implicit Racial Bias

In the investigation of implicit racial bias (using the Implicit Association Test, IAT) I contrasted self-resembling, same-race, and other-race faces using a quadratic model where self- and same-race bias were predicted to be higher than the other-race condition. Analysis revealed that amygdala activation correlated positively with the IAT score. This contrast revealed activation in several areas of the brain such as: the left frontal operculum (z

= 3.46; -46, -18, 4), left postcentral gyrus (z = 3.69; -38, -18, 38), left precentral gyrus (z = 3.16; -62, -2, 10), and the right and left paracingulate gyrus (z = 3.09; 0, 54, 16). In a subsequent ROI analysis a correlation between IAT *D* scores (Greenwald, McGhee, and Schwartz, 1998) and percent signal change for ROI's localized to the left (*r(11) = -0.497, p = .05*) and right amygdala (*r(11) = -0.380, p = .112*) was evident (See 5.3.). Furthermore, a correlation between ACC activation to same-race and other-race faces as a function of IAT *D* score (*r(11) = .400, p = .09*) was not significant.

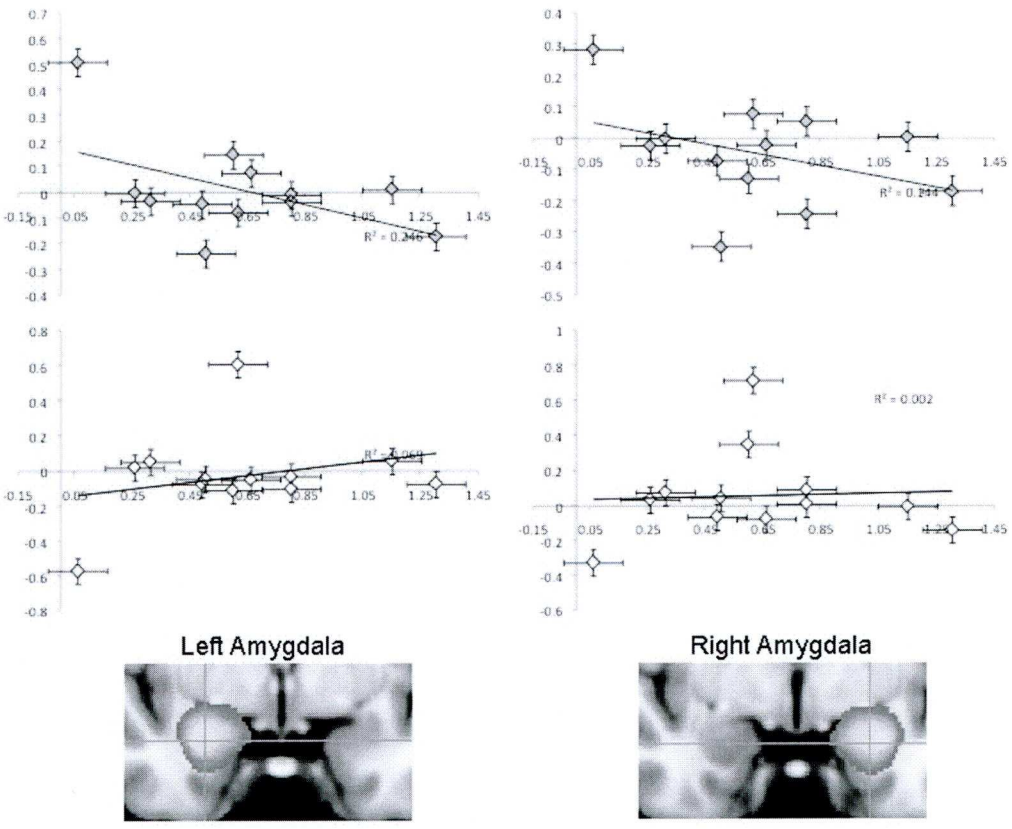


Figure 5.3. Implicit Associations Test Correlation with Amygdala Activation. Plots show correlations between IAT *D* scores and percent signal change for ROI's localized to the left and right amygdala. Decreases in left (*r(11)=-0.497, p=. 05*) and right (*r(11)=-0.380, p=.112*) amygdala to same-race

condition (gray diamonds) and only slightly increasing left amygdala activation to other-race condition (white diamonds).

5.4. Discussion

In summary, results indicated that activation in the ACC varies as a function of resemblance to the participant when individuals are excluded. Activation in the ACC increased during exclusion conditions as the other players' facial resemblance to the participants increased. Although it was predicted that the activation from the different conditions would fit a linear function (i.e. self-resemblance > same-race > other-race), findings showed increased activation in the ACC in both the same-race and self-resembling conditions. The activation in the ACC was less during the other-race exclusion condition, indicating that individuals have a stronger neurological response to exclusion by members of self-referential and same-race in-group. This is not entirely surprising; as past research has suggested that cues of relatedness (self-resemblance, shared ethnicity, MHC similarity) engender positive pro-social feelings (DeBruine, Jones, and Perrett, 2005; Platek et al., 2009; Rushton, 1984). Individuals show a preference towards familiar stimuli; which, at the most basic level, would include individuals of the same race. It would be very helpful in teasing apart the result if I had run analyses showing facial resemblance activations for the participants. Because I do not have proof of these activations, I cannot show that the increase in ACC activation during the self-resembling exclusion condition is unequivocally related to the fact that the other players resembled the participant. So while I am drawing the conclusion that the increase in ACC activation is most likely related to being excluded by self-resembling individuals, I can't determine that with any degree of accuracy. I will say that after the experiment many of the participants asked or commented that they felt like the other players looked like them.

So from an anecdotal perspective, participants did seem to recognize that they shared resemblance with the other players.

Individuals do not only show impact in brain activation, but participants also reported a decrease in satisfaction of four basic needs (belonging, control, self-esteem, and meaningful existence) when excluded. However, contrary to my prediction, participants' ACC activations showed a correlation to self-reported needs satisfaction in the same-race exclusion condition only. I hypothesized that there would be a correlation among the ACC activation and the self-resembling condition as well. Perhaps self-resembling and other-race faces represent the opposite ends of a self-referential distribution. For instance in the self-resemblance condition, one could be upset by exclusion from this class of stimuli, generally, without evaluation. On the other hand, exclusion by an other-race face is not upsetting because this class of stimuli may represent an out-group membership. However, in the same-race condition the players may represent persons who are members of the same social group, and whom might share genes in common with the participant. Perhaps in this instance, in the absence of ostensible cues to relatedness, the emotional feelings about the situation and the person modulate one's reactions to exclusion. That is, the lower individuals' rate their feelings of control and self-esteem, the more it hurts to be excluded by this person. It suggests that exclusion by individuals outside of our kin or other race groups is modulated by feelings and needs associated with that person or group, but this idea demands more research.

Additionally, findings showed that activation in the ACC was correlated with activation in the right and left VPFC during the other race exclusion condition. I did not predict this activation pattern. It was hypothesized that activation in the VPFC would increase as activation in the ACC decreased, particularly during the self-resembling and same-race exclusion conditions. The VPFC is involved in the regulation and inhibition of the social pain

response during exclusion (Eisenberger et al., 2003). It is possible that I found a positive correlation between ACC activation and VPFC activation in the other-race condition because activation in the ACC was low to begin with in this condition. Alternatively, perhaps I found different activation patterns between the ACC and the areas of the frontal cortex than the previous study (Eisenberger et al., 2003) because this study displayed faces to represent the other players. Thus, I may have unwittingly introduced another component that the frontal cortex was attending to in place of mediating ACC activation. Haxby et al., (2002) describe the OFC (which I refer to as VPFC in this paper as they are in close proximity and overlap) as part of a neural system that participates in face perception and discuss its role in evaluating potential reward. This area seems to be instrumental in evaluating the information in faces that is relevant to social reinforcement, such as identity and expression (see Rolls, 1996). It is plausible that VPFC activation was positively correlated with ACC activation in this study, particularly in the other-race condition, because the participants were paying specific attention to and assessing the faces for cues to emotional expression, as well as identity.

Finally, the results supported the hypothesis regarding the IAT and neural activation. Individuals who showed increased positive bias towards same-race images, showed a trend towards increased activation in the left and right amygdala during the other-race exclusion conditions. I also found a significant decrease in amygdala activation in the left amygdala in the same-race exclusion round. This suggests that as IAT score increased (implicit bias against other race increased), participants showed a decrease in left amygdala activation when excluded by the same race faces. This finding supports previous research regarding the importance of the amygdala in response to in- and out-group determinations and judgements (Phelps, O'Conner, Cunningham, Funayama, Gatenby, Gore, and Banaji, 2000). Phelps et al. (2000) found that amygdala activation was correlated

with both IAT reaction time as well as a startle eye-blink response when white participants were shown black faces. Thus, it appears that the amygdala is a primary component in the neural system involved in the indirect appraisal of social groups.

Overall, the current result showed that individuals respond differentially to exclusion based upon level of resemblance to one's self and one's same-race group. These findings are significant in understanding how people respond to others in social situations based upon two important social cues: race and kinship. The results show that sharing race tends to make exclusion a more powerful and negative experience whereas exclusion by an other-race individual has less of an impact. This experiment adds to Williams' classification model of ostracism. The race of the target of exclusion as well as the race of the source of exclusion are important factors in exclusion falling under two categories: the *Moderators or Mediators* module (target's race) and the *Antecedents* module (source's race and similarity to the target). The target's race, as well as the source's race and resemblance to the target, impacted the target's response to exclusion via a decrease in the fundamental needs and increased neural activation in the ACC. Unfortunately, I was not able to identify the mechanisms by which exclusion was more distressing in response to self-resembling and same-race faces. One possibility might involve differences in the feeling of development of a closer bond with the other players during the game. This would be a fertile area for future research.

Chapter 6 Hyperscanning and the Neural Correlates of Social Cooperation

6.1. Introduction

As Axelrod and Hamilton (1981) point out in their seminal work on the evolution of cooperation, "The theory of evolution is based on the struggle for life and the survival of the fittest. Yet cooperation is common between members of the same species and even between members of different species" (p.1390). This suggests that cooperation, as well as competition, is employed as integral to facilitating survival. Kin selection theory (Hamilton, 1964) describes why individuals and animals would cooperate and behave altruistically toward genetically related individuals. It has been illustrated that both humans and other animals are more likely to engage in acts of reciprocity and cooperation with those who share genes in common with them; that is, within the realm of natural selection cooperation can be favourable if the recipient of the altruistic act is genetically related to the individual performing the act because of the incurred benefits to genes dispersed throughout one's family (i.e. the cost of cooperation is presumed to be dissipated by the fact that the benefits are being received by an individual who shares genes in common with the cooperator, hence the cooperation may actually be serving one's own genetic information; Hamilton, 1964; Nowak, 2006). However, the theory of kin selection does not fully explain why humans (and some other species) have evolved to cooperate beyond the realm of their kin and often do so in ways were reciprocity is not direct or instantaneous.

6.1.1. Direct and Indirect Reciprocal Altruism

Both direct and indirect reciprocal altruism require a more complex system of analyses to determine whether it is truly beneficial to partake in such cooperation. Rather than genetic relatedness requirements, direct reciprocal

altruism is determined by the probability of repeated encounters (Axelrod and Hamilton, 1981; Nowak, 2006). Nowak (2006) has created an equation to demonstrate the relationship between probability of repeated encounters and the cost benefit analysis for cooperating: $w > c/b$. The probability of meeting a cooperator again (w) must be greater than the cost (c) to benefit (b) ratio. Furthermore, Axelrod and Hamilton (1981) argue that cooperation in a Prisoner's Dilemma game (which simulates and examines cooperation between two people) will most likely be beneficial if one adopts a tit for tat strategy. That is, if someone cooperates in the previous round, then in turn the other person will also cooperate in a subsequent round. Trivers (1971) generated a parsimonious philosophy regarding reciprocal altruism: if I cooperate now, then perhaps you will cooperate later (See also Nowak, 2006). While this line of thinking makes sense, it is difficult to imagine how indirect reciprocity would be beneficial to human evolution. In the instance of indirect reciprocity, one person has something to give and the other has nothing, and the likelihood of them ever meeting again is low. In this case it actually may pay to cooperate if helping the individual will bolster one's reputation (Nowak, 2006). Therefore, reputation can serve as the reward or benefit to cooperation. Research has illustrated that those who are helpful are more likely to receive help from others: "Natural selection favours strategies that base the decision to help on the reputation of the recipient" (Nowak, 2006, p. 1561). In other words, a boost to one's reputation can be beneficial and can be seen as a reward for cooperating (Nowak, 2006; Nowak and Sigmund, 1998). Despite all of this, there must be a mechanism in place to help individuals to resist the temptation to defect and not reciprocate altruism (Frank, 1988).

6.1.2. Social Exclusion and Cooperation

In many ways defecting from cooperation can be beneficial; one can reap the benefits of others' good faith and cooperation at no cost to themselves.

In order for cooperation to work there must be a mechanism through which those who cheat are punished (Kurzban and Leary, 2001). In a one-on-one exchange, defection can be easily detected, and it can be combated by defection from the other member of the dyad. Social exclusion is a strategy that can be used to punish defectors in larger group situations. Ouwerkerk et al. (2005) reviewed research by Axelrod and Hamilton (1981) as well as Nowak and Sigmund (1998), and they proposed, "Social exclusion of non cooperating members may in fact sustain cooperation in situations where other mechanisms such as direct and indirect reciprocity fail" (p. 329). Furthermore, when a "bad apple" is introduced to the group other members have a tendency to mimic the "bad apple's" behaviour and defect (Ouwerkerk et al., 2005). Group members seem to cooperate at a level that is slightly higher than the least cooperative member; this is also called minimal reciprocity. The threat of ostracism can help to assuage this trend and increase cooperation among group members. This might occur because of an inherent fear of exclusion as well as the fact that exclusion represents a greater cost than cooperating. Results from Ouwerkerk et al.'s (2005) research suggests, "The mere threat of ostracism could attenuate the bad apple effect even when exclusion did not have any economic costs, suggesting that the anticipated psychological costs of ostracism are sufficient to deter people from following the bad example of an uncooperative other" (p.325).

As these forms of reciprocity and consequences of defection become more complex, a more complex system is required to untangle all the details. For instance, cognitive demands increase because one has to remember his interactions as well as keep tabs on the relentlessly shifting social dynamics in the group (Nowak, 2006). Additionally, because indirect reciprocity depends upon reputation, which can be built by gossip, the ability to form language is necessary; language is the mechanism for spreading gossip. Nowak and Sigmund (2005) presume that indirect reciprocity and language have been

integral in the development of human intelligence (cf. Dunbar, 1992). These factors help to explain why humans are one of the only species to practice indirect reciprocity and for whom it is a successful strategy (Nowak, 2006). Furthermore, the human brain appears to guide humans in realising that accepting altruism without reciprocating is only beneficial in the short-term. Human beings have the capacity to weigh long-term rewards and consequences resulting in decisions that allow for the survival of mutual cooperation (Rilling et al., 2002; Frank, 1988).

6.1.3. Neural Correlates of Cooperation: Theory of Mind

Human primates have the most sophisticated self-awareness of all animals; they are endowed with the ability to represent their own physical and mental states including motoric, mental, emotional, perceptual, and visceral (Gusnard, 2006). This highly developed sense of self-awareness has allowed humans the unique capacities to not only think about themselves but to also consider the states of mind in others (Gallup, 1982; cf. Platek et al., 2004; Vogeley et al., 2001). Certainly, mentalizing about the self can be a helpful tool when mentalizing about others (Davis and Stone 1995a; Davis and Stone, 1995b; Mitchell et al., 2006). If one can't think about himself and his own state, it would be difficult to consider another person's state. Many of the same parts of the brain used for self-reflection are used for mentalizing about others (Mitchell et al., 2006; Platek, 2006; Saxe, 2006). Theory of mind (ToM) is a distinct aspect of social cognition in humans (and great apes), allowing one to make inferences about the mental states of others (Rilling et al., 2004; Premack and Woodruff, 1978). It is the cornerstone of the human ability to deceive, empathize, cooperate, and to assess body language (Gallagher and Frith, 2003). Gallagher and Frith (2003) state, "It (ToM) underlies our ability to explain and predict the behaviour of ourselves and others by attributing to them independent mental states such as beliefs, desires, emotions, or

intentions" (p.77). Research has indentified a series of neural structures that form a network which appears to be active during theory of mind (ToM). This network includes, but may not be limited to, the following structures: anterior paracingulate cortex, posterior superior temporal areas, tempo-parietal junction, and the temporal pole (Rilling et al., 2004; Saxe and Kanwisher, 2003; Gallager and Frith, 2003). There is also support for ToM activation in the amygdala, medial frontal cortex, orbital frontal cortex/frontal pole (Stone, 2006; Stone et al., 1998, Stone et al., 2003; Fine et al., 2001; Frith and Frith, 2003; Stuss, Gallup, and Alexander, 2001). It is important to note that the areas between the frontal pole and the anterior cingulate cortex are not only involved in ToM, but also in self-reflection and assessing other's thoughts and perceptions (Lissek et al., 2008).
Studies incorporating cooperation and defection have shown that the purported reward system in the brain is involved in ToM and decision-making (Rilling et al., 2002; Glimcher et al., 2008). For instance, Rilling et al. (2002) discovered that activation in the anteroventral striatum and in the subgenual anterior cingulate cortex (ACC) with connections to the caudate and nucleus accumbens (key reward substrates that receive midbrain dopamine projections) are involved with reward processing (see also Schultz, 1998). Another reward processing area (Rolls, 1999) was also activated: the ventromedial/orbitofrontal cortex (OFC). This activation was evident after participants chose the lesser rewarding game outcomes: cooperation from both partners (CC) and defection from both (DD). These outcomes, however, may be reinforcing because they are stable.
Theory of mind is essential in the current study because the primary aim is to determine what occurs in the brain when two people work together, or cooperate, to complete a task. I hypothesized that activation in the ToM network would be significantly greater when participants were working together compared to when they completed the task on their own. In particular the ToM network would be active when participants were in the

instruction condition (a more in depth discussion of my hypotheses can be found in section 6.1.4.).

6.1.4. Hyperscanning and Hypotheses

Hyperscanning (Montague et al., 2002) involves the linking of two, or more, fMRI scanners allowing participants to interact with each other during real-time behavioural tasks. King-Casas et al. (2005) describe hyperscanning as follows: "The motivating idea behind this approach is simple: To probe neural substrates of social interactions, we scan the brains of multiple subjects engaged in social interaction" (p. 78). Collecting data on both brains at the same time allows for the researcher to have a record of the neural processes of both participants' behaviour. The unique prospect of acquiring brain imaging data simultaneously while two brains are working together has the possibility of increasing the chance of finding important neural relationships and could lead to the development of new approaches to and increased understanding of the neural basis of social interactions and cooperation (Montague et al., 2002). However, hyperscanning can be a very challenging means of data collection. In this study many of the benefits of hyperscanning were counterbalanced by the drawbacks of having to account for different field strengths, coordinating precise timing, and complicated analyses. While Montague et al. (2002) and King-Casas et al. (2005), as cited above, describe many of the benefits of hyperscanning, it can be a difficult means of data collection. Its main benefits for this study were 1) the expedited data collection process, since two subjects were scanned at once, and 2) participants were able to interact and respond to the task in real time.

My goal in this study was twofold: 1) to determine whether areas in the putative ToM neural network were activated when participants worked together to complete the task and 2) most importantly, to compare the pattern of activation when participants completed the maze by themselves

to activation when completing the maze in cooperation with the other participant. I predicted that there would be increased activation in the ToM network and reward centres when participants worked together. Furthermore, I hypothesized that in instances where participants completed the maze while instructing their partner, activation in the reward network would be higher than the activation in the reward network when completing the maze alone in the self-drive condition.

6.2. Methods

6.2.1. Procedure

Participants (n = 28, 14 pairs; M_{age} = 24.5; SD_{age} = 4.04; 18 females; 10 males) were recruited from the University of Liverpool and the surrounding community via the University of Liverpool announcement system to take part in this experiment. The University of Liverpool School of Biological Sciences Committee on Research Ethics approved the study. All participants provided signed informed consent and met criteria for MRI scanning. Participants were randomly assigned to either of the two scanners available for research use at MARIARC. Pairs of participants were pseudo-randomly assigned based upon availability of both participants and availability of both scanners.

6.2.2. Paradigm

To examine the neural correlates of cooperation participants were asked to work together to complete a series of mazes. In this interactive task both subjects cooperated in real time to reach the end of a maze. A form of "blind driving" was used which required the participants to rely upon one another and work together to reach the end of the maze. Participant A is called the instructor. The instructor can view the maze field; however he cannot interact with the maze. In order to navigate the maze he must send

directions, using the keypad, to his partner, Participant B, or the driver. The driver then receives the instructions, which appear in the form of numbers, and are coordinated with directional instructions (left, right, forward, and backward). The driver presses the appropriate button on his keypad to move through the maze, but he is blind to the maze environment. This would be tantamount to getting into the driver seat of an automobile with a blindfold on and taking instructions on what actions to take from the passenger (e.g., press accelerator, press brake, turn left, right, stop, etc). See Figures 6.1. and 6.2. for a visual display of the maze environment and the hyperscanning set up.

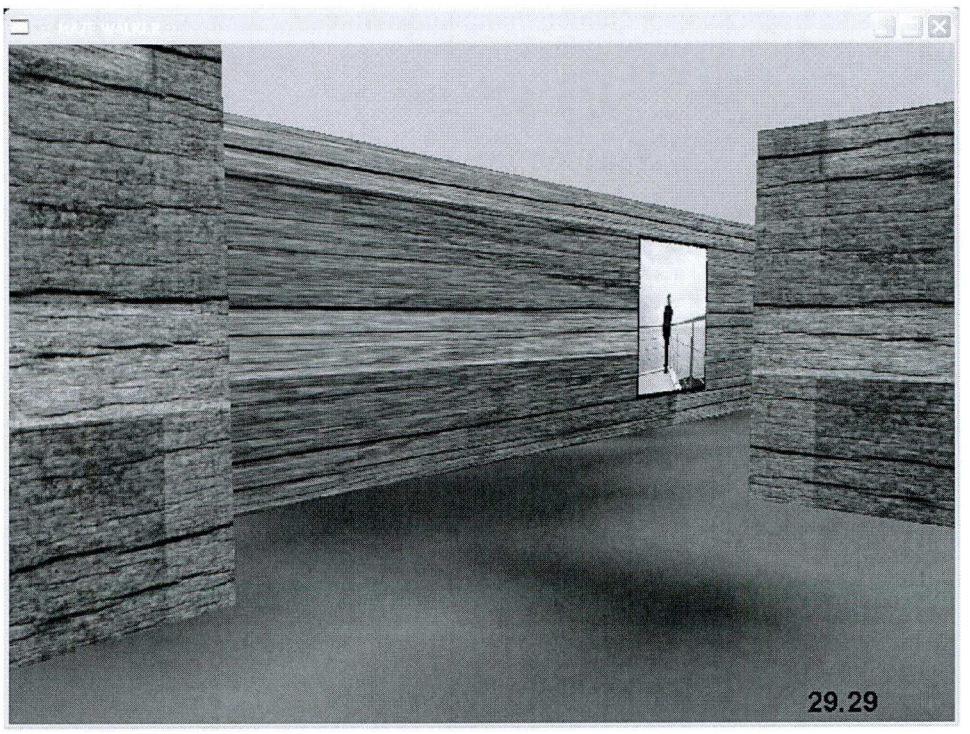


Figure 6.1. A View of the Maze Environment

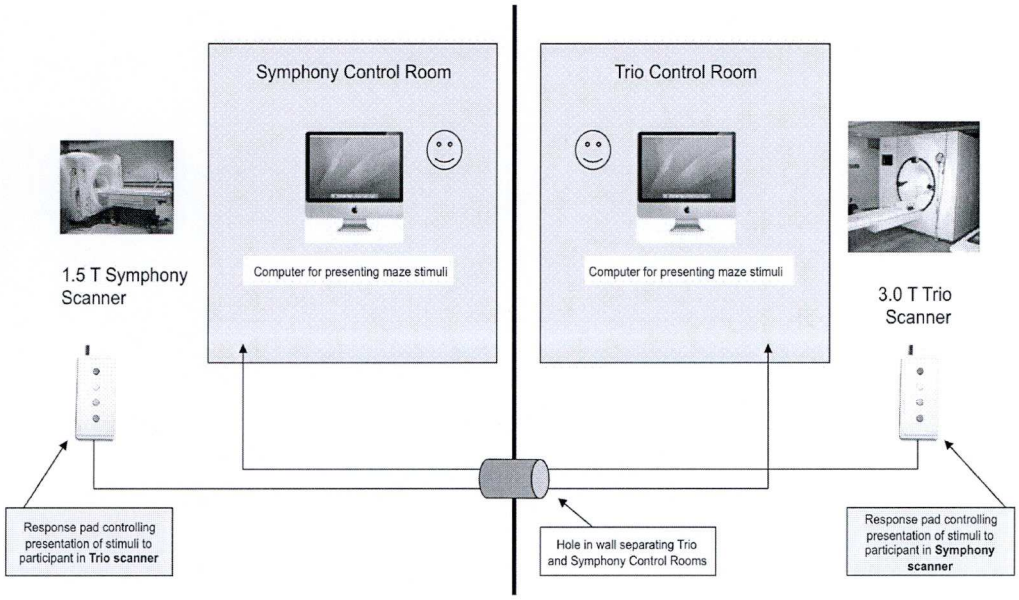


Figure 6.2. Visual Display of the Hyperscanning Design

Sixty seconds was allotted for the completion of each maze. Mazes were presented in pairs of 2 with a 20 second rest (scrambled image screen) at the beginning, end, and in between mazes. Participants undertook the role of instructor for four mazes (instruct condition), completed 4 mazes on their own (self-drive condition), and finally undertook the role of driver (drive condition) for 4 mazes. Participants were randomly assigned a starting role as instructor or driver and participants completed the self-drive condition while the other participant received their structural scan to reduce overall time in the scanner environment.

Because this task proved challenging, participants had an opportunity to become familiar with the task and to practice using the keypad outside of the scanner. Furthermore, they were given a very specific series of instructions regarding how to operate the keypad and navigate the maze prior to, and after, entering the scanner. Instructions were repeated as needed while participants were in the scanner.

The maze task used in this experiment is not a typical ToM task. One might question the degree to which this paradigm qualifies as a ToM task

because the task did not require both participants to think about what the other participant was thinking or feeling. However, the instructing partner was required to consider the driver's point of view at all times, thus requiring ToM. While this experiment is not the ideal ToM experiment, this task requires the use of theory of mind. For instance, would any other organism other than a human, who has advanced theory of mind, be able to complete this task? My prediction would be no. Therefore, according to this rationale I would like to argue that while this experiment may not be an *ideal* ToM paradigm, it is assessing a specific component of ToM. Furthermore, experts in the ToM field describe the advantage of ToM as follows: "Through having ToM we can recognize that another person's knowledge is different from our own. I know what's behind the rock, but he doesn't because from where he is he cannot see that there is a scorpion. Having a ToM allows us to manipulate other people's behaviour by manipulating their beliefs. If he is my friend I can warn him about the scorpion. If he is my enemy I can tell him it is safe… Human interactions predominantly involve the dissemination of true or false knowledge for good or ill" (Frith and Frith, 2005, R644). In the maze experiment, for example, the instructor knows that the driver can't see the maze environment, so he or she could trick the driver by directing him or her into the wall, never allowing him or her to complete the maze. Now this was avoided in this task because the instructor and the driver shared the established goal of reaching the end of the maze, but the instructor could use his or her knowledge about the driver's knowledge to trick him or her as mentioned in the Friths' example. (Note: in the example of driving the car blindfolded, this might be dire for both driver and passenger). Frith and Frith (2005) go on to explain that understanding another person's point of view different from one's own involves "a translation between egocentric and allocentric spatial co-ordinates." This ability to translate between the self and the other is essential in spatial navigation, and in development the

ability to solve spatial viewpoint problems occurs concurrently with the ability to solve false belief tasks (Frith and Frith, 2005). According to the aforementioned definition and description I believe that this task does involve ToM as it is described above. The instructor was required to think about what the driver knows or sees or is thinking. The instructor has to consider the driver's knowledge and then proceed with giving him or her instructions about the maze. Additionally, the instructor can see the driver's progress through the maze, so he or she can see that the driver either understands or does not understand the directions (i.e. he or she must think that I said to go left, when in fact I meant for him or her to turn right…). These types of ToM issues were encountered consistently through the task. So, overall the task appears to be a ToM task for the instructor, but for the driver it is more of an instruction following task.

6.2.3. Imaging Parameters

Participants were scanned at the University of Liverpool's MARIARC, using one of two scanners: Siemens Symphony 1.5 Tesla and a Trio 3 Tesla scanner. Each sequence was optimized (with the assistance of the resident radiographer) to make the imaging parameters as analogous as possible across scanners in an effort to make comparison more accurate. In the Symphony scanner, functional images were collected using an EPI sequence (TR = 3000 ms, TE = 45 ms, FOV 192x192 mm, slice thickness = 3.5 mm, gap = .5, number of slices = 35). Participants also underwent a 7-minute structural scan (MPRAGE: 176 slices, TR = 2040 ms, TE = 3.93 ms). The remaining participants were scanned using a Trio 3T scanner (TR = 3000 ms, TE = 30 ms, FOV = 192x192 mm, slice thickness = 3.0 mm, gap = 3.3 or 10%, number of slices = 42). The parameters of the MPRAGE structural scan are the same as above except that the TE = 5.5 ms. Participants were given instructions on how to navigate the maze using an MRI compatible response pads (Current Designs, www.curdes.com). All

participants completed 2 driving runs, 2 self-driving runs, and 2 instructing runs. As noted above (See Section 6.2.2.) each run consisted of 2 mazes for a total of 4 mazes per condition. This allowed all participants to complete each portion of the experiment.

6.2.4. fMRI Imaging analysis and Contrasts Part 1

For pre-processing and statistical analysis of the fMRI data I used the FMRIB Software Library (www.fmrib.ox.ac.uk/fsl). Single subject pre-processing was done for each participant, correcting for motion using MCFLIRT (Jenkinson and Smith, 2002) and brain extraction using the BET tool (Smith, 2002). Images were also intensity normalized and smoothed (full width half max = 6). All higher-level analyses were performed using fMRI Expert Analysis Tool (FEAT) version 5.98 part of FSL (Smith, 2002) and mixed effects modelling. After the pre-processing, I created first level contrasts for each condition: drive, self-drive, instruct. Then I entered them into higher-level mixed effects analyses to get the combined results from both scanners: collapse drive (drive condition 1.5T + drive condition 3T), collapse instruct (instruct condition 1.5T + instruct condition 3T), collapse self-drive (self-drive condition 1.5T + self-drive condition 3T), collapse instruct versus collapse drive (collapse instruct – collapse drive), collapse self-drive versus collapse instruct (collapse self-drive – collapse instruct), collapse self-drive versus collapse drive (collapse self – collapse drive). Finally contrasts were combined for the pair (drive + instruct conditions) versus self-drive contrast ([collapse drive + collapse instruct] – [collapse self-drive]) and the self-drive versus pair contrast ([collapse self-drive]- [collapse drive + collapse instruct]) to show the activation when one participant is instructing and the other is driving and they are working together to solve the maze. All higher level contrasts were set to a $z = 2.3$, $p < 0.05$, unless otherwise stated.

6.3. Results Part 1

6.3.1. Instruct Condition

First level Instruct contrasts were collapsed across both scanners. Images were thresholded ($z > 2.3$) using corrected clustered significance threshold of $p < .05$ unless otherwise stated. Activation was evident in the following areas: bilateral frontal pole, bilateral medial frontal gyrus, right precentral and postcentral gyrus, right subparietal lobe and right inferior temporal gyrus. Furthermore, there was activation in areas that have been implicated in the ToM network: the precuneus, left anterior cingulate gyrus (ACC), the left superior temporal gyrus, and bilateral medial temporal gyrus (See Table 6.1. for coordinates).

6.3.2. Self-Drive Condition

First level self-drive contrasts were collapsed across both scanners. The following areas showed significant levels of activation during this task: bilateral orbitofrontal cortex, bilateral precentral and postcentral gyrus, bilateral posterior middle temporal gyrus, right paracingulate gyrus, and left precuneus cortex (See Table 6.2. for coordinates).

Table 6.1. Instruct Condition Coordinates and Activation.

Anatomical Region	**Right/Left**	***X***	***Y***	***Z***	**Z-score**
Frontal Pole	R	-22	42	24	4.94
Frontal Pole	L	-20	40	38	4.66
Precuneus cortex	L	-4	-40	68	5.98
Superior temporal gyrus	L	-56	-24	4	5.74
Medial frontal gyrus	R	22	36	22	4.42
Medial frontal gyrus	L	-26	32	36	4.51
Anterior cingulate cortex	L	-4	10	28	5.75
Inferior temporal gyrus	R	52	-54	-8	3.75

Precentral gyrus	R	50	8	40	4.4
Postcentral gyrus	R	6		68	6.11

6.3.3. Drive Condition

No voxels survived cluster correction in the collapsed drive condition.

6.3.4. Collapsed Instruct versus Collapsed Self-Drive Contrast

This contrast reveals activation that survived after all activation from the instruct condition was combined and then the collapsed activation from the self-conditions was subtracted (collapse instruct – collapse self). This contrast illustrates which areas were more active in the instruct conditions (e.g. what sets them apart from the self-drive condition). The areas where activation was seen are: occipital pole, left precuneus, left inferior temporal gyrus, and right lateral occipital cortex.

Table 6.2. Self-Drive Condition Coordinates and Activation

Anatomical Region	**Right/Left**	***X***	**Y**	***Z***	**z-score**
Postcentral gyrus	R	54	-56	26	4.24
Orbitofrontal cortex	R	42	24	-6	5.16
Oribitofrontal cortex	L	-40	32	-8	5.13
Lateral occipital cortex	R	36	-70	40	4.19
Medial temporal gyrus (posterior)	R	62	-36	-2	5.46
Medial temporal gyrus	L	-56	-52	6	5.9
Paracingulate gyrus	R	4	28	44	5.12
Precuneus Cortex	L	-]4	-40	68	5.98

6.3.5. Collapse Self-Drive versus Collapse Instruct Contrast

No activation survived this contrast.

6.3.6. Collapse Self-Drive versus Collapse Drive Contrast

Activation survived this contrast in the left inferior frontal gyrus, precuneus cortex and posterior cingulate gyrus, right paracingulate gyrus, and left middle temporal gyrus.

6.3.7. Pair versus Self-Drive Contrast

This contrast combined the driving and instruct conditions and contrasted them against the self-driving condition ([collapse drive +collapse instruct] – self-drive). Significant activation was evident in the precuneus cortex, orbital frontal cortex, postcentral gyrus, supramarginal gyrus (anterior and posterior division), left caudate and putamen, as well as the lateral occipital cortex. Areas associated with reward are active in this contrast suggesting that participants feel more reward when working together to solve the maze relative to when they work on their own (See Table 6.3.).

6.3.8. Self-drive versus Pair Contrast

In this contrast the self-drive condition was contrasted with the paired driving and instruct conditions (self-drive – [drive + instruct]). Activation was found in the inferior frontal gyrus, precuneus, posterior cingulate gyrus, paracingulate, and middle frontal gyrus (See Table 6.3.).

Table 6.3. Pair versus Self-Drive Contrast. Activation coordinates and z-scores from *Pair versus Self-Drive* (top) and *Self-drive versus Pair* (bottom)

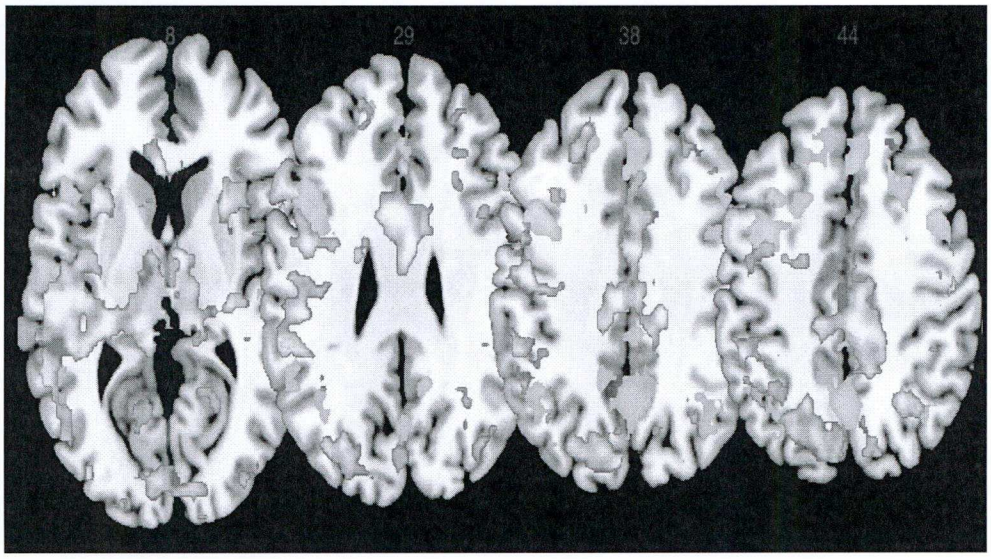
Pair Activation	**Hemisphere**	**X**	**Y**	**Z**	**z-score**
Precuneus Cortex	L	-8	-56	62	4.28
Superior Frontal Gyrus	L	-22	4	-12	4.88
Postcentral Gyrus	L	-28	-40	44	3.91
Supramarginal Gyrus (anterior and posterior)	L	-28	-40	44	3.91
Superior Parietal	L	-12	-60	62	3.68

Lobule					
Putamen	L	-22	2	-6	4.23
Caudate	L	-16	18	0	3.88
Lateral Occipital Cortex	R	34	-88	6	3.48
Occipital Pole	R	36	-88	10	3.36
Self Activation					
Inferior Frontal Gyrus	L	-46	16	18	4.86
Precuneus	L	-2	-58	42	4.68
Superior Frontal Gyrus	L/R	0	20	52	4.02
Paracingulate Gyrus	R	6	24	54	3.84
Middle Frontal Gyrus	L	-44	10	34	4.68
Posterior Cingulate Gyrus	R	12	-52	34	4.04

6.4. Discussion Part 1

Participants showed increased activation in putative ToM substrates (e.g. precuneus cortex, OFC, supramarginal gyrus, paracingulate gyrus) and reward centres (e.g. caudate and putamen) when cooperating with others (See Tables 6.1., 6.2., and 6.3.) The activation patterns for the collapsed instruct condition (occipital pole, left precuneus, left inferior temporal gyrus, and right lateral occipital gyrus) suggest that participants were recruiting parts of the ToM network to process information as they gave instructions. In fact, substrates associated with the ToM network were evident in all of the contrasts: instruct, self-drive, pair versus self-drive, and self-drive versus pair. Because the task required instructing participants to think about their behaviour in all conditions, as well as to consider the actions of others, the ToM network activation makes sense. Even in the conditions were the person was working alone, some of the same areas that are recruited for thinking about others may be recruited. I will discuss this in more detail in a later portion of the discussion.

Figure 6.3. Collapse Self-Drive and Collapse Instruct. Overlay of Collapse Self-Drive (yellow) and Collapse Instruct (blue). Figures are in neurological orientation.



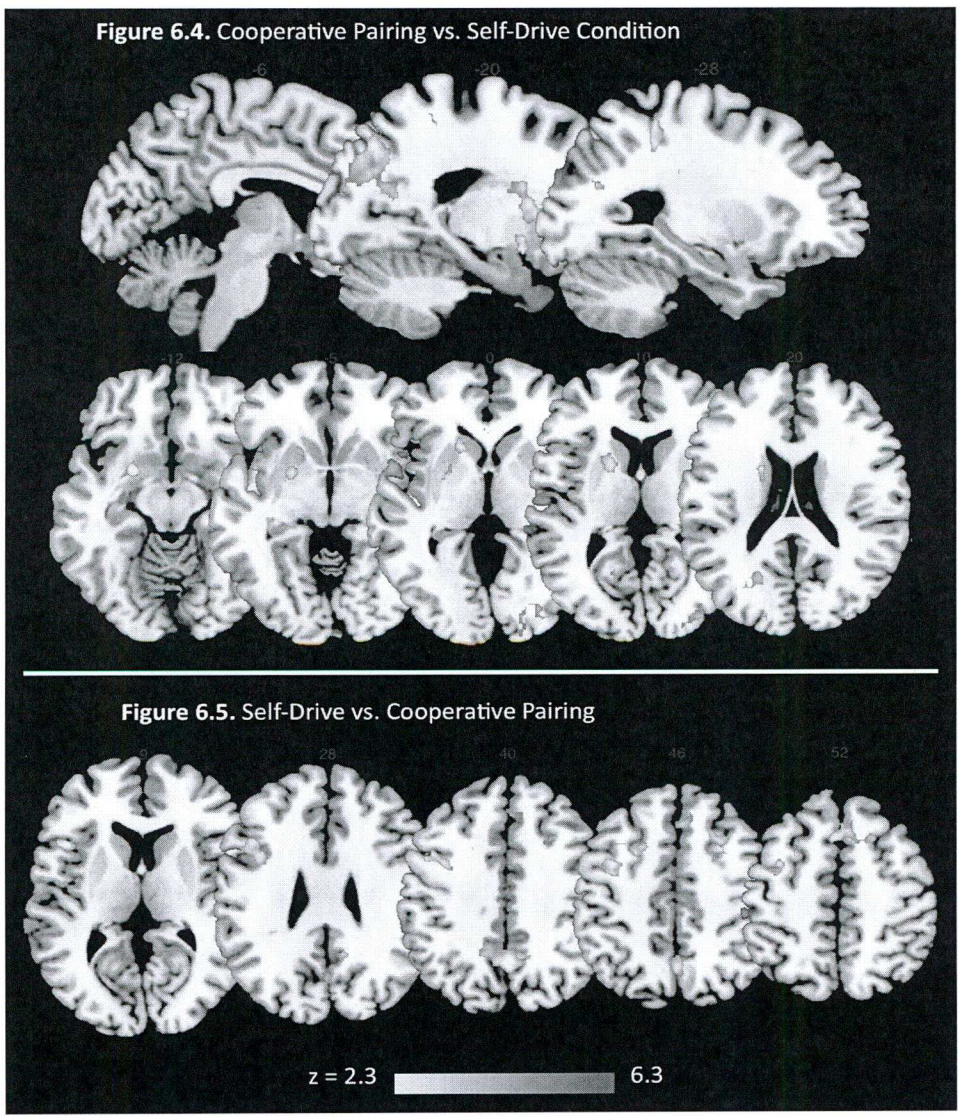
First, precuneus activation was present in all conditions. Activation in the precuneus has been associated with mentalizing about cooperation. Lissek et al. (2008) report that in stories describing deception, cooperation, or combined cooperation and deception the precuneus seems to be particularly involved in processing information pertaining to cooperation. In part, the findings correspond to this suggestion, as the instructor was working to cooperate with the driver on the maze task, activation was evident in the precuneus. The findings of Ochsner et al. (2004) also provide support for this idea. They argue that the left precuneus is one of the regions activated when attributing emotions to other people and the self (see Lissek et al., 2008). Because of the connections between activation in the precuneus and mentalizing about the self and others, finding activation in the precuneus in all conditions of this study is not surprising (cf. Lou, 2004; Platek, Mohamed, and Gallup, 2005). Additionally, the precuneus has also been connected to visuo-spatial imagery. Cavanna and Trimble

(2006) reported that the precuneus is linked to motor imagery and abstract mental imagery tasks. Because of the nature of the maze task, some of the precuneus activation may be related to the visuo -spatial imagery which is occurring while participants try to complete the maze task.
Furthermore, activation in the superior and medial frontal gyri was evident in all of the conditions and evident in all contrasts that survived thresholding. Lissek et al. (2008) reported activation in the superior frontal gyrus and the medial frontal gyrus in response to cooperation stories. Activation in these areas has been related to both cooperation and deception, but there were some differences in the degree of activation given the type of story (e.g. cooperative or deceptive) (Lissek et al., 2008). Portions of the superior frontal gyrus and the medial frontal gyrus are also considered part of the medial prefrontal cortex (with connections to the OFC) and are consistently reported in ToM tasks (Brune and Brune-Cohrs, 2006; Amodio and Frith, 2006; Saxe and Kanwisher, 2003; Saxe, 2006; Lissek et al., 2008). Intuitively, it makes sense that activation would be present in these parts of the brain as past research has shown that the medial prefrontal cortex and the ACC are implicated in making the distinction between self and other (Lissek et al., 2008; Platek et al., 2006; Vogeley et al., 2001.). During the instruct condition one could interpret these findings as suggesting that participants were thinking about what they were doing and what needed to be communicated to their partner-participant to facilitate movement through the maze.

6.4.1. Overlap in Neural Activation on Self-Drive and Instruct Conditions

The self-drive condition revealed activation in many of the same substrates that were active in the instruct condition. An overlap in the brain areas associated with working alone to complete a task and cooperating with another person emerged in this condition; that is, participants may have been thinking about one's self in a situation and possibly modelling the

mental state of another (Gallup, 1982, Vogeley et al., 2001; Platek et al., 2004). Many of the same areas recruited for self-reflection are also recruited for ToM (Lissek et al., 2008). Johnson et al. (2002) found anterior medial prefrontal activation and posterior cingulate activation in their examination of self-reflection. A similar situation arose in this study. Participants in the self-drive condition showed activation that overlapped with the pair drive and instruct activation, suggesting that the active substrates may not be specifically self-reflective of ToM functions, but that they are involved in metacognitve functioning, generally.



6.4.2. Executive Function and Reward: OFC Activation

In this experiment the collapsed self-drive condition showed activation in areas associated with executive function and reward. The lateral orbital frontal cortex (OFC) showed bilateral activation. In an attempt to tease apart the functions of the OFC, Elliott et al. (2000) hypothesized that the lateral OFC is heavily involved in the decision making process in situations that are "incompletely specified" and in suppressing previously rewarded responses (p. 310). Circumstances requiring individuals to make judgments with an incomplete set of information creates an element of unpredictability, and this appears to activate areas of the lateral OFC (Elliott et al., 2000). Furthermore, Elliott et al.'s (2000) research supports that the OFC monitors reward values, and in a novel (or uncertain) situation an appraisal can be made resulting in appropriate response evaluation and selection. Knutson and Cooper (2005) reported that lateral OFC and caudate activation was evident in instances of short-term reward prediction. In accordance with this Tanaka et al., (2004) discovered that "when subjects learned actions on the basis of immediate rewards, significant activity was seen in the lateral orbitofrontal cortex and the striatum" (p. 887).

These findings provide support for the role that the OFC may have played in the present study. Participants were unsure of the outcome of the task and the OFC may have been integral in assessing the task and making decisions about how to proceed. Additionally, the OFC may have also been activated upon the immediate anticipation and receipt of the reward, which was the completion of the maze[1]. In particular the OFC may have been linked to the reward system in the pair versus self-drive contrast, as the

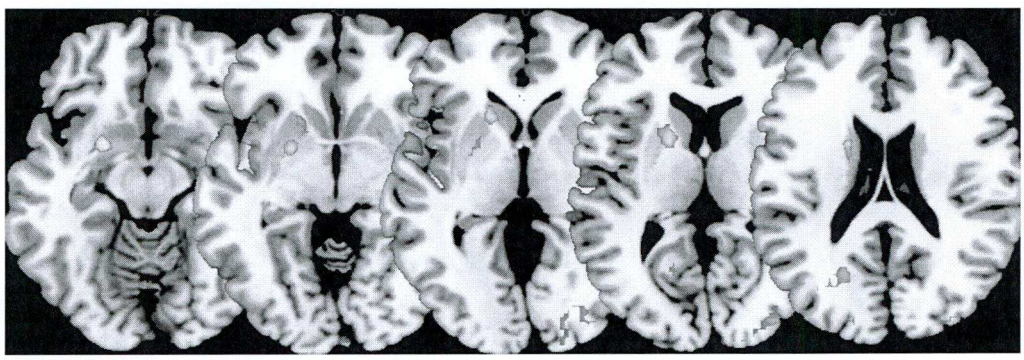
[1] While I did not experimentally assess how participants felt after the scanning, many participants anecdotally reported during my debriefing that they felt a particular sense of accomplishment when they instructed the other person to the completion of the maze. I can recall many subjects reporting the feeling of success, and that they felt a sense of pride and reward upon successfully completing the mazes.

caudate nucleus and putamen, areas that have been implicated in reward (Glimcher et al., 2008) were also active. It is my interpretation that where other components of the reward network are activated the OFC activation is likely linked to reward activation. However, it is important to note with structures like the OFC it is hard to know with certainty exactly what it is being responded to because it has myriad of functions (Elliott et al., 2000).

6.4.3. Reward Centre Activation

In the pair versus self-drive condition activation was evident in three areas associated with reward: OFC, caudate, and putamen (Figure 6.6.). The caudate and nucleus accumbens are known for their reward response (Glimcher et al., 2008), and they receive dopamine projections from the midbrain (Rilling et al., 2002; Schultz, 1998). It appears that the OFC is essential in the control of goal directed behaviour (Schultz et al. 2000; Damasio, 1994; Rolls, 1996). Lesions of the OFC lead to impaired decision-making regarding the outcome of actions (Bechara et al., 1998). Because rewards are imperative to the primary goals of behaviour, human motivation may be linked to the processing of reward stimuli in the OFC (Dickenson and Balleine, 1994). In other words, positive reinforcement is one of the primary functions of rewards, and the OFC is integral in this process.

Figure 6.6. Activation in the Caudate in the Pair versus Self-Drive Condition.



The ultimate goal in this study was to examine how cooperating (two minds working together on a task) differed from doing the task alone. The control task, or self-drive condition was designed to provide a basis of comparison for activation when one is working alone. While there was a great deal of overlap in the self-drive condition and the instruct condition, there was a distinct difference in the pair (or combined brain vs. the self-drive). Reward centres in the brain were active in the pair contrast. Thus, it appears that variation in the reward system is activated depending upon whether one completes the maze alone or in cooperation with another person. This activation difference might suggest that the participants experienced some anticipation about the successful completion of the maze via communication with their partner. While it is rewarding to complete the maze by oneself, as evidenced by activation in the OFC, it may be more rewarding to complete the task under conditions of real time cooperation. Activation in the OFC was evident in this contrast and most importantly caudate and putamen activation was present. The activation in the caudate and putamen is unique to this contrast, and these parts of the brain seem to play a special role in cooperation and reward (Schultz, 1997). Knutson et al., (2001) dissociated parts of the reward system network and found that anticipation of reward resulted in activation in the caudate and the putamen, whereas notification that the reward was earned revealed activation in the medial prefrontal cortex. Glimcher et al. (2008) report that the caudate is associated with cooperation when one is making decisions about social reward for their partners during a game. Rilling et al. (2002) report activation in the caudate and anterior cingulate gyrus following cooperation in a Prisoner's dilemma game. Specifically, this response is isolated to the condition where participants were cooperating with another human being. Perhaps the caudate and putamen are particularly sensitive to human interaction and the rewards associated with it. As Rilling suggests (2008) the incorporation of the reward system in cooperative interactions

has helped to lay the groundwork and maintain human cooperation among individuals who are not kin.

6.5. Part 2

In this portion of the analysis I compared brain activation between those who completed the maze and those who did not complete the maze. Ultimately, comparisons were made between these four conditions: Instruct Complete (IC), Self Complete (SC), Instruct Did Not Complete (IDN), and Self Did Not Complete (SDN). Comparisons were made between all possible conditions.

Table 6.4. Description of the Conditions

Condition	**Description**
Instruct Complete (IC)	The maze was completed during the instruct condition.
Self Complete (SC)	The maze was not completed during the self-drive condition.
Instruct Did Not Complete (IDN)	The maze was not completed during the instruct condition.
Self Did Not Complete (SDN)	The maze was not completed during the self-drive condition.

6.5.1. fMRI Imaging Analysis and Contrasts Part 2

In the second part of the analysis, the same pre-processing and statistical analyses were performed in the same way as discussed previously (See Section 6.2.4. for a review). After pre-processing I created first level contrasts at the individual level for the all of the instruct and self-drive conditions. The drive conditions, except for self-drive, were not included in the contrasts because participants were not given feedback about whether or not the maze was completed; therefore they did not know if they had

successfully completed the maze or not. In the second level analysis, conditions were contrasted at the individual level. For example if a participant completed the maze during the self-drive condition in the first part of the round, but did not complete it in the second part of the round (*remember that each maze set has 4 mazes- 2 pairs of 2 mazes), and then completed both rounds of the mazes during the instruct condition then his contrast would be something like this: self-drive complete – self-drive not complete; self-drive complete – instruct complete; self-drive not complete – self-drive complete; self-drive not complete – instruct complete; instruct complete – self-drive not complete; instruct complete – self-drive complete. In other words, each participant's condition was contrasted at the individual level with the other possible outcomes.

Third-level analysis brought everything to the group level. Contrast Parameter Estimate (COPE) files were combined for all participants that fell into each category. Using the previous example, that participant's COPE files would have been combined with other participants' for each contrast. So all participants COPE files were combined under the proper category to create group activation means. FMRI data processing was carried out using FEAT (FMRI Expert Analysis Tool) version 5.92, part of FSL (FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl). Z (Gaussianised T/F) statistic images were thresholded at $p = .05$ (uncorrected). Images were thresholded ($z > 1.6$) using non corrected significance threshold of $p < .05$ unless otherwise stated.

6.6. Results Part 2

Activations for all contrasts are described below. Additionally, the coordinates and z-scores are listed in Table 6.4.

6.6.1. Instruct Complete versus Instruct Did Not Complete (IC – IDN)

This contrast compared those who completed the maze during the instruct condition versus those who did not complete the maze when they were instructing. Activation was evident in the following areas of the brain: left caudate, bilateral temporal lobes, left posterior cingulate gyrus, and left putamen.

6.6.2. Instruct complete versus Self Did Not Complete (IC-SDN)

Brain activation from the IC condition (those who completed the maze during the instruct condition) was contrasted with that from the SDN (those who did not complete the maze during the self-drive condition) condition. Activation was evident in the right and left frontal lobes, precentral gyrus, precuneus cortex, paracingulate gyrus, superior frontal gyrus, middle frontal gyrus.

6.6.3. Instruct Complete versus Self Complete (IC – SC)

In this contrast, activation was contrasted between participants who finished the maze during the instruct condition and participants who completed the maze during the self-drive condition. Activation appeared in the following substrates: left precentral gyrus, right precuneus, cerebellum, left superior frontal gyrus, right lingual gyrus, right postcentral gyrus, left post central gyrus, left precentral gyrus.

6.6.4. Instruct Did Not Complete versus Self Did Not Complete (IDN-SDN)

This contrast revealed activation that remained after a contrast between those that did not complete the maze during the instruct condition (IDN) and those that did not complete the maze during the self-drive condition (SDN). Activation was evident in the following substrates: right precuneus cortex, right postcingulate gyrus, left posterior cingulate gyrus, left

precuneus cortex, left superior frontal gyrus, middle temporal gyrus posterior division, left inferior temporal gyrus, and left lateral occipital cortex.

6.6.5. Instruct Did Not Complete versus Instruct Complete (IDN-IC)

Brain activation of participants who did not complete the maze during the instruct condition was contrasted with that of those who completed the maze during the instruct condition. Activation was evident in the following substrates: bilateral middle frontal gyrus, right precentral gyrus, left paracingulate gyrus, right supramarginal gyrus posterior division, left anterior cingulate gyrus, left paracingulate gyrus, bilateral superior frontal gyrus, left precuneus, bilateral anterior cingulate gyrus, right precuneus cortex.

6.6.6. Instruct Did Not Complete versus Self Did Not Complete (IDN-SDN)

This contrast revealed activation which remained after the IDN group was contrasted with the SDN group. Activation was evident in the following substrates: left post central gyrus, bilateral middle temporal gyrus (posterior division), bilateral orbital frontal cortex, bilateral superior frontal gyrus, posterior cingulate gyrus, precuneus,

6.6.7. Self Did Not Complete versus Instruct Complete (SDN-IC)

No activation evident.

6.6.8. Self Did Not Complete versus Self Complete (SDN-SC)

This contrast revealed activation remaining after a contrast between SDN and SC groups. Activation was evident in the following substrates: right superior frontal gyrus, bilateral frontal pole, bilateral orbital frontal cortex,

paracingulate gyrus, superior frontal gyrus, right pallidum, insular cortex, right putamen, right caudate.

6.6.9. Self Did Not Complete versus Instruct Did Not Complete (SDN-IDN)

Activation was evident in the following areas of the brain in the SDN versus IDN contrast: right precentral gyrus, right superior parietal lobule, right insular cortex, middle frontal gyrus.

6.6.10. Self Complete versus Instruct Did Not Complete (SC-IDN)

In this contrast activation from the participants that completed the maze by themselves was contrasted with that of participants who did not complete the maze during the instruct condition. Activation was evident in the following substrates: left middle frontal gyrus, left putamen, left precentral gyrus, left precuneus cortex, bilateral anterior cingulate gyrus, right insula, caudate, planum polare, and left supramarginal gyrus (posterior division).

6.6.11. Self Complete versus Self Did Not Complete (SC-SDN)

Activation was evident in the following substrates: Bilateral paracingulate gyrus, right anterior cingulate gyrus, left posterior cingulate gyrus, bilateral precuneus cortex, bilateral middle frontal gyrus, left precentral gyrus, bilateral inferior frontal gyrus, bilateral frontal pole, left supramarginal gyrus.

6.6.12. Self Complete versus Instruct Complete (SC-IC)

Activation was evident in the left anterior cingulate gyrus, bilateral frontal pole, caudate, paracingulate gyrus, bilateral superior temporal gyrus (posterior division), bilateral middle temporal gyrus, and the precuneus cortex.

Table 6.5. Complete versus Incomplete by Instruct and Self-drive Conditions Activations

	Hemisphere	X	Y	Z	Z-score
IC-SDN					
Frontal lobes	L	-16	16	50	2.93
Precentral gyrus	L	-38	-22	50	2.30
Precuneus	L	-2	-60	40	1.93
Paracingulate	L	-6	20	46	2.62
Superior frontal gyrus	L	-24	16	46	1.98
Middle frontal gyrus	L	-40	22	30	2.85
IC-IDN					
Temporal occipital fusiform gyrus	L	-32	-50	-20	1.80
Temporal occipital fusiform gyrus	R	28	-44	-18	2.07
Caudate	L	-18	-26	22	2.00
Posterior cingulate gyrus	L	-4	-24	28	1.83
Putamen	L	-26	16	4	2.33
Juxtapositional lobule cortex	L	-14	-16	44	2.01
Juxtapositional lobule cortex	R	12	-8	50	2.13
Anterior cingulate cortex	R	12	4	36	1.93
Superior frontal gyrus	L	-28	-12	62	1.68
Precentral gyrus	L	-30	0	32	2.43
IDN – IC					
Middle frontal gyrus	L	-24	2	52	2.25
Middle frontal gyrus	R	26	2	52	1.71
Precentral gyrus	R	26	-10	44	2.38
Paracingulate gyrus	L	-2	20	44	1.96
Supramarginal gyrus	R	44	-44	44	2.68
Anterior cingulate gyrus	L	-4	6	30	1.64
Anterior cingulate gyrus	R	2	0	32	2.79
Superior frontal gyrus	R	24	2	48	1.81
Superior frontal gyrus	L	-22	2	56	2.23
Precuneus	L	-4	-52	52	1.62

IC – SC					
Precentral gyrus	L	-34	-22	50	2.16
Precuneus	R	14	-50	62	1.62
Cerebellum	R	26	-50	-32	2.43
Superior frontal gyrus	L	-18	0	62	1.71
Lingual gyrus	R	22	-40	-8	
Supramarginal gyrus	L	-22	-40	38	2.49
Postcentral gyrus	L	36	-28	50	2.07
Superior parietal lobule	L	-22	-52	50	2.63
SC – IC					
Anterior cingulate gyrus	L	-2	36	16	2.49
Frontal pole	L	-20	52	16	3.81
Frontal pole	R	22	54	16	3.48
Caudate	L	-14	10	16	3.01
Caudate	R	16	8	16	2.24
Paracingulate	L	-2	48	18	2.87
Superior temporal gyrus (posterior)	L	-60	-34	4	2.97
Superior temporal gyrus (posterior)	R	58	-34	2	3.97
Middle temporal gyrus	R	62	-32	-4	3.087
Middle temporal gyrus	L	-60	-32	-2	2.33
Precuneus	L	-2	-38	52	3.06
IDN – SDN					
Precuneus/post cingulate gyrus	R	8	-52	32	2.04
Cingulate gyrus	L	-4	-48	16	2.07
Cingulate gyrus	R	2	-38	18	1.72
Superior frontal gyrus	L	-20	38	46	2.22
Middle temporal gyrus	R	58	-14	-22	1.86
Anterior cingulate gyrus	L	-54	-22	-22	1.70
OFC	L	-48	20	-8	1.82
OFC	R	50	22	-8	1.64
SDN – IDN					
Precentral gyrus	R	44	0	50	1.65
Superior parietal lobule	R	44	-44	60	
Insula	R	34	16	8	1.63
Middle frontal gyrus	R	34	2	62	1.63
SDN – SC					
Superior frontal gyrus	R	8	44	40	1.63

Frontal pole	L	-40	44	-10	1.89
Frontal pole	R	32	44	10	2.44
OFC	L	-32	22	10	2.43
OFC	R	22	22	-12	
Paracingulate gyrus	L	-8	22	44	2.09
Superior frontal gyrus	R	6	46	42	1.92
Pallidum	R	14	0	-6	1.97
Insula	L	-32	20	-8	2.51
Putamen	R	20	22	-6	1.92
SC – SDN					
Paracingulate	L	0	22	44	2.61
Paracingulate	R	6	-44	-4	1.77
Anterior cingulate gyrus	R	6	14	20	1.78
Posterior cingulate gyrus	L	0	-38	26	2.64
Precuneus	L	0	-62	40	2.12`
Precuneus	R	4	-60	50	1.94
Middle frontal gyrus	R	40	32	26	2.56
Middle frontal gyrus	L	-38	32	26	2.03
Inferior frontal gyrus	L	-48	14	26	2.36
Inferior frontal gyrus	R	50	20	26	2.04
Frontal pole	R	50	38	-4	1.63
Supramarginal gyrus	L	-38	-36	38	2.10
SC – IDN					
Middle frontal gyrus	L	-32	36	26	1.60
Putamen	L	-32	10	-2	1.58
Precentral gyrus	L	-12	-34	46	3.18
Precuneus	L	0	-58	38	2.51
Anterior cingulate gyrus	R	0	36	-4	1.98
Insula	R	36	20	-2	1.88
Caudate	L	-14	16	0	1.82

6.7. Discussion Part 2

When the IC (Instruct Complete) activation was contrasted with IDN (Instruct Did Not Complete) and the SC (Self Complete) was contrasted with IC (Instruct Complete) conditions substrates of the reward system in the brain were activated, specifically the OFC/MPFC, caudate and

putamen. Additionally reward network activation survived several of the other contrasts, and this activation appears to be linked to completing the maze by oneself or during the cooperation condition, but the main component is that the reward areas are active during successful maze completion.

Precuneus activation was evident in a majority of the contrasts. It has been well documented that precuneus activation is related to self-processing (Cavanna and Trimble, 2006). The capability to distinguish between one's own perspective and another's perspective is essential in theory of mind which allows one to recognize and act upon the knowledge that another person's perspective or knowledge is different from one's own. Cavanna and Trimble (2006) state, "Overall, it emerges that the intentional self component is an important factor in precuneus involvement. These results fit well with Damasio's hypothesis (1999), according to which medial parietal areas, together with the secondary somatasensory cortices and insula, help to subserve the primitive representation of the self in relationship with the outside world (proto-self)" (p. 576).

Activation in the theory of mind areas was also evident. In all of the instruct contrasts, regardless of whether the maze was completed, activation in the ToM network was evident: orbitofrontal cortex, anterior cingulate cortex, temporoparietal junction, temporal lobes, and the precuneus. In the self-drive contrasts, some of the same ToM areas showed activation particularly the frontal pole, paracingulate cortex, and the anterior cingulate cortex, which have been related to self-reflection (Lissek et al., 2008). Lissek et al. (2008) state, "The area extending from the anterior cingulate cortex to the anterior frontal pole, particularly the paracingulate cortex, is supposed to be engaged in self-reflection, person perception and in making inferences about others' thoughts" (p. e2023). Overall, these contrasts did not reveal, nor were they meant to, anything particularly different from the previous contrasts regarding theory of mind

and reward. The main aim in running these analyses was to take a closer look at the relationship between the reward activation and completion of the maze.

A higher level contrast was run between (IC – IDN) – (SC – SDN) and (SC – SDN) – (IC –IDN) to investigate the unique brain activation between instruct complete and self complete conditions, controlling for activation in the instruct did not complete (IDN) and the self did not complete (SDN) conditions. Results indicated that the caudate and putamen were significantly more active ($p < .05$) in the (IC – IDN) – (SC – SDN) contrast. This means that in the incidents where the participants were working together and completed the maze, activation in the putamen and caudate, reward centres of the brain, was significantly stronger than in the conditions where participants completed the maze alone. Haruno and Kawato (2006), suggest that the caudate and putamen serve the following functions: "The putamen is involved mainly in evaluating actions in terms of sensory contexts and rewards, whereas the caudate nucleus is involved mainly in comparing actual and predicted rewards for learning" (p. 948). Knutson et al. (2001) suggest that putamen and caudate activation are related to anticipation of reward. Furthermore, this finding appears to provide support for my previous conclusion that the caudate and perhaps the putamen as well, may be uniquely related to the reward that accompanies engaging in successful cooperation to achieve a goal with another human being or the anticipation of such a reward.

6.8. General Discussion

6.8.1. Limitations

One limitation in this study is the interscanner variability. When using two different scanners it is necessary to account for the different operating characteristics between scanners. For instance, scanners may have

different gradient strengths, head coil sensitivity, and different gains (Montague et al., 2002). In an effort to account for this in my study I attempted to optimize the sequences of both scanners to limit differentiation to a minimum. This was done via repeated consultation with the resident radiographer at MARIARC. Additionally, the use of a task like the maze task, which is not a well developed ToM task, complicated things. Investigating ToM and reward when working together could have been accomplished using a more established task, and this could have improved the study.

6.8.2. Conclusion

This study has shown that the theory of mind network is associated with cooperation in this task and considering the other participant's instructional requests/needs. Additionally, many of the same neural correlates associated with cooperation are also incorporated in self-reflection, as evidenced by the activation patterns in the self-drive condition. Most importantly, activation in the caudate nucleus and putamen was apparent only when the participant was cooperating and working with the other participant, in the combined brain contrast. In the second part of the study results indicated that in fact, caudate and putamen were the unique remaining activations in the critical contrast between the instruct complete condition and the self complete conditions: (IC – IDN) – (SC – SDN). This suggests that participants found it more rewarding to complete the maze with their partner, than to complete it alone. I think that this unique activation may suggest that there is a particular part of the reward system, possibly residing in the caudate or putamen, that is involved in the reward associated with human social interaction. However, caudate and putamen activation was still evident in some of the self complete contrasts, as well as the other instruct complete conditions. So while it may be most rewarding to complete the maze during a cooperative effort, it is still

rewarding to complete the maze by oneself. Overall, this study demonstrated that working together to complete the maze resulted in the greatest activation in the caudate and putamen reward areas, compared to other conditions. Future research may provide evidence to support that these areas are part of a unique network that is more responsive to cooperation and success when working with a human partner.

Chapter 7 General Discussion

7.1. Social Exclusion and Cooperation

The dynamics underlying social exclusion and cooperation are intricate and multifarious (Maner et al, 2007). The experiments presented in this thesis were designed to dissect the nature of responses to exclusion and cooperation, and to this end I attempted to research variable responses at the behavioural, cognitive, and neurological levels. Each experiment provides an important link to the role of social exclusion and cooperation during human evolutionary history, as well as adding to the understanding of the individual variability in responses to social exclusion as applied to Williams' model of ostracism. Generally, what is well known, and is reiterated in this thesis, is that social exclusion is hurtful and distressing, and cooperation is pleasing and beneficial. I replicated the social exclusion effect several times here and also show that dyadic cooperation is pleasant. This begs the question, "What is new and potentially important about this thesis?" First, if one accepts the notion that exclusion is hurtful (e.g. impacts fundamental needs) as true, then what this thesis does is help describe the contexts – psychological and social – under which experiences associated with exclusion vary across participants.

In Part 1 of my thesis (Chapters 3 and 4) I have shown that being excluded is hurtful regardless of 'brain type' and that exclusion is so psychologically powerful that it appears to capture portions of the attentional systems indiscriminately. Because of the unwavering nature of the behavioural and cognitive responses of my participants, I feel that this suggests that social exclusion was likely a recurrent threat experienced by our hominid ancestors and thus variance in psychological brain type (empathizing, systemizing) has little effect on the experience. Rather, in the latter case of cognitive responses (Chapter 4), it appears that exclusion is powerful

enough to impact executive functions significantly. Albeit this is conjecture at this stage, this could serve to allocate attentional resources to incidents of exclusion producing quick and efficient modifications in behaviour aimed at regaining inclusion. As noted throughout this thesis, inclusion/group membership brings with it many benefits, not the least of which are protection, sharing of resources, and possibility of allo-mothering, thus making inclusion and group membership a coveted status. In Part 2 of this thesis (Chapters 5 and 6) I utilized fMRI brain imaging to "peer" into the brain in order to gain deeper insight into 1) a potentially evolutionary important context that might drive variation in experience of distress due to social exclusion (in versus out-group exclusion) and 2) the neural correlates of shared cooperation. In the former (Chapter 5), data showed that group membership and facial self-resemblance had an impact on the neural correlates associated with brain activation to social exclusion. Specifically, participants showed activation consistent with a neural alarm response hypothesis when being excluded by "players" that shared some type of appearance based group membership (my proxies for group membership were same-race and self-face resemblance). When exclusion came at the hands of individuals who might share group membership (same-race) or genes in common with the participants (self-resemblance), activation in specific areas of the brain intensified. In the latter (Chapter 6) I specifically investigated the neural correlates of cooperation during a real-time cooperative task. In this task participants had to cooperate with one another in order to reach the end of the maze. The relationship between the areas activated in response to cooperation suggests that this exercise was rewarding (i.e. that solving the maze activated shared reward centres across the two participants' brains). To me, this suggests that evolution may have favoured cooperation since the brain appears to show reward centre activity in response to cooperation.

One could theorize that the reward activation I observed is the proximate neural correlate to the ultimate benefits of cooperation. In other words, cooperation in groups tends to result in sharing of resources, protection, and survival, and these benefits appear to have capitalized on activation in the reward system in the brain. This, I think, can be clearly linked to social exclusion. Exclusion poses a threat to the fundamental needs such that it requires that humans are vigilant of their level of social inclusion, and have a system in place by which they respond with the appropriate coping strategies when in danger of exclusion (Ouwerkerk et al., 2005; Leary et al., 1995; Pickett and Gardner, 2005). Indeed, possession of a system with such a purpose is indicative of the magnitude of the threat of exclusion, suggesting that it is a tool that can be employed by groups to encourage behaviours, particularly behaviours that benefit the group. Consequently, cooperation is rewarded and can be promoted by the threat of exclusion (Kerr, 1999). Below I summarize my main findings in more detail and draw some final conclusions about this research.

7.2. Summary of Findings

7.2.1. Summary of Chapter 3

In Chapter 3 results indicated that cognitive style, specifically empathizing and balanced cognitive style, impacted participants' perceptions of control during the Cyberball game. Social exclusion impacted the participants' fundamental needs independent of cognitive style; however this experiment revealed that empathizers have different needs than systemizers when it comes to the amount of control they feel comfortable with in social interactions. Therefore, an individuals' cognitive perspective, present during any social interaction, appears important to sociality. Interestingly, this suggests that a degree of individual variation exists surrounding the target of exclusion and responses to actual exclusion and threats of

exclusion. Baron-Cohen (2003) has suggested that cognitive style – empathizing to systemizing – is a trait that selection acted on during our human evolutionary history. He suggests that this spectrum can best be represented as a continuum between extreme male-like and extreme female-like psychological/cognitive tendencies, thus lending to the selection for the division of labour among the sexes in early hunter-gatherer societies. My finding suggests that those closer to the extreme female-like cognitive style are more attuned to threats of exclusion; specifically they feel a heightened loss of control. This corresponds with the division of labour hypothesis which suggests that females were more likely to spend significantly more time in proximity to other – other females, young males, and children – relative to adult males who might have had to spend long periods in isolation during hunting excursions. While my results did not reveal any gender differences, this may have been as a result of the fact that most of the participants in this study did not fall into the extreme empathizing and extreme systemizing categories; however empathic individuals did differ from the other groups on their need for control during the Cyberball game.

7.2.2. Summary of Chapter 4

Chapter 4 focused on the impact of exclusion on cognitive processing in the excluded target. The results indicated that exclusion caused a delay in cognitive processing, generally attention. Participants demonstrated a latent response time on the emotional Stroop task, with no specificity effect for word class. This suggests that participants' attention was captured when excluded, which I assume are either attempts to suppress their emotional distress or to channel cognitive resources towards regaining inclusion. The relationship between the four fundamental needs and their ties to anxiety (losing sense of belonging, control, self-esteem, and lack of meaningful existence lead to anxiety), provide support for the latter, suggesting that

anxiety directs attention to problem areas and this channelling of attention is a mechanism by which people quit doing things that may jeopardize inclusion and allow them to re-evaluate their behaviour and look for a way to regain inclusion (Baumeister and Tice, 1990).

7.2.3. Summary of Chapter 5

Group membership impacts the effects of social exclusion. The fMRI study in Chapter 5 showed that activation in the ACC varies as a function of resemblance to the participants when individuals are excluded. The ACC has been linked to social distress (Eisenberger et al., 2003; 2006; Masten, 2009) and I discovered that activation in the ACC increased during exclusion conditions when the other players' shared race and facial self-resemblance. In other words, there was a stronger neurological response to exclusion from in-group/same-race members and self-resembling faces. These findings suggest that exclusion can be impacted by *who* is doing the excluding. This is consistent with literature on kin selection (Hamilton, 1964). For example, DeBruine (2002) showed that self-resembling faces are trusted more than non-self-resembling faces and Platek and his colleagues have shown similar trustworthy and appetitive behavioural responses to self-resembling faces (Platek et al., 2002, 2003, 2004, 2005, 2007). Similarly, there appears to be a distinct neural response to faces of the same race, relative to other race faces (Phelps et al., 2000). Other-race faces tend to activate areas associated with anxiety and fear, namely the amygdala. Although most of the neuroimaging studies on same versus other-race faces are across ostensible phenotypic groups (white versus black faces), one could conjecture that similar mechanisms exist even where these ostensible phenotypic variations are not apparent to you or I. Take for example primitive African tribes that would appear to resemble one another in skin colour. I would hypothesize that across these groups individuals can efficiently detect out-group members and would behave

accordingly and show similar neural activation patterns, and this would be an interesting area of further research.

7.2.4. Summary of Chapter 6

Finally, Chapter six shifts direction a bit to investigate cooperation during an fMRI hyperscanning task. When comparing across conditions of instructing versus self-driving many of the same areas (precuneus, postcentral gyrus, frontal pole/prefrontal cortex) showed activation. Activation in the theory of mind network was also evident, especially in the instructing condition (precuneus, anterior cingulate gyrus, superior temporal sulcus, and medial temporal gyrus). Aside from this, the most compelling finding was the activation in substrates associated with reward (orbital frontal cortex, caudate, and putamen) that was evident when contrasting cooperating brains with instances of those participants working in isolation. The unique activation in the caudate and putamen suggests that there is a specific part of the neural reward system that is involved in the rewards associated with human cooperation (Rilling et al., 2002). Additionally, results indicated that when participants successfully completed the maze with their partner activation in the putamen and caudate areas was stronger compared to those instances when the maze was successfully completed alone.

7.2.5. Implications for the Ostracism/Social Exclusion Model (Williams, 1997/2007)

What is the sum of all of these parts? Well, at the outset it may have seemed that the two themes incorporated in this thesis were unrelated: social exclusion and cooperation. However, I hope that I have now made it apparent that there is the possibility of cyclical relationship between the two – the nature of which is outside the scope of one thesis. It was my goal to demonstrate that putative evolved cognitive adaptations modulate

feelings and neural correlates associated with social exclusion and cooperation. Linking these important mechanisms of human social behaviour with neural activation associated with exclusion and cooperation leads to a better understanding of how social groups are formed and the proximate mechanisms that regulate social group maintenance.

So, at it the most basic level, cooperation may be considered adaptive because it allows humans to work together, share resources and protection. Furthermore, ostracism eliminates burdensome members from the group to maintain group cohesion (Williams, 2007). Under these assumptions, cooperation and social exclusion appear to be a system of checks and balances that have evolved to work together and each provides support for the other. The first three experiments (Chapters 3, 4, and 5) focus on social exclusion. Chapters 3 and 5 illustrate that responses to social exclusion can be idiosyncratic and are affected by characteristics of the target *and* the source. Chapter 4 indicates that cognition/attention is impacted by social exclusion, and basic cognitive processes are stalled because of the negative impact of social exclusion. Humans have evolved a brain and biology whose functioning benefits from the formation of and maintenance of sociality and when that is disrupted individuals feel a decreased sense of belonging, control, self-esteem, and meaningful existence (Cacioppo and Hawkley, 2005). This was evident in my experiments, although not all of the needs were impacted equally. Furthermore, these findings add additional information to Williams' ostracism model (1997; 2007), which provided the theoretical framework for this research (See Figure 7.1.).

These experiments have illustrated that race, self-resemblance, and brain type can act as mediating and moderating variables in exclusion. Moreover, exclusion impacts cognitive processing, and the results of Chapter 4 are applicable to the *Reactions* module, suggesting that a temporary inhibition of cognitive processing results from exclusion. Figure

7.1. illustrates the application of the research in this thesis to William's model for social exclusion.

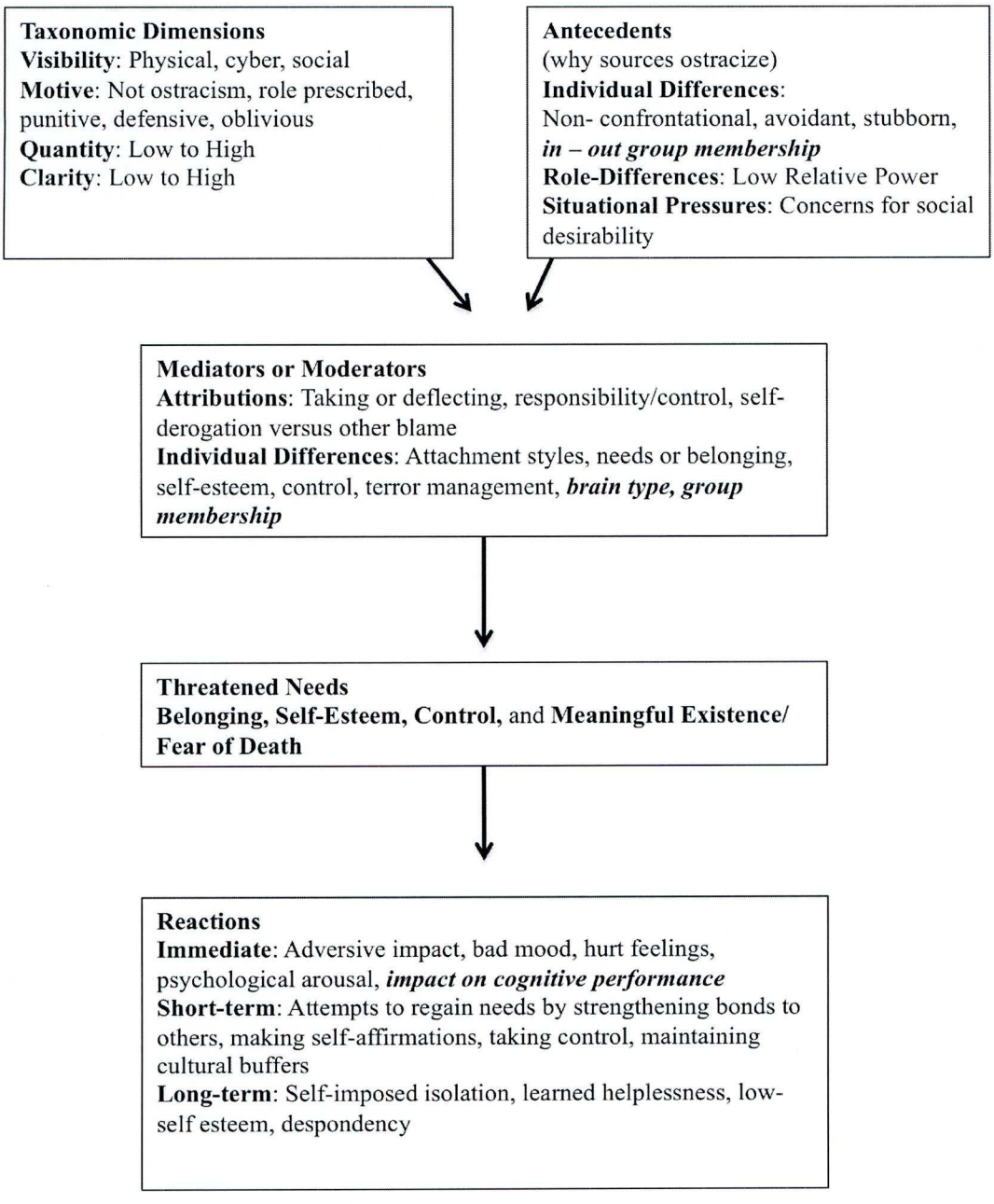


Figure 7.1. Williams' (1997) Model of Ostracism with applications from this thesis in bold italics.

Additionally, exclusion activates areas of the brain involved in physical and emotional pain, and the social pain system may have piggy backed off of the pre existing pain system (Eisenberger et al., 2003). This may suggest that humans have evolved to avoid social exclusion and rejection (just like we avoid physical pain), which are detrimental to survival and mental well-being, and to enjoy cooperation and to find it pleasurable and rewarding. When feelings of inclusion and belonging are threatened people feel distressed and anxious and are motivated to regain inclusion, which is rewarding. Because exclusion has been fingered as a strategy for maintaining group cohesion and norms, it is likely that human biology evolved to support that. Therefore, cooperation has developed to be a rewarding experience for human beings. Activation in the reward centres of the brain (the striatum, caudate, nucleus accumbens and the OFC) may be helpful in "sustaining cooperative relationship(s)" because of their importance to survival and as a counter to the costs associated with exclusion (Ouwerkerk et al., 2005). Exclusion may have evolved to keep people honest among group living situations, and the anxiety that accompanies it may work to motivate individuals to regain inclusion and to regain the rewarding experience of cooperation. See Figure 7.2. for a hypothesized insertion of cooperation into William's model of social exclusion.

7.3. Conclusions

7.3.1. Future Directions

Expanding upon the social exclusion experiments using techniques other than Cyberball would be interesting. While Cyberball is a very good way to create an exclusive environment for a study in laboratory settings, it may have specific effects that accompany it. For instance, I did not find that

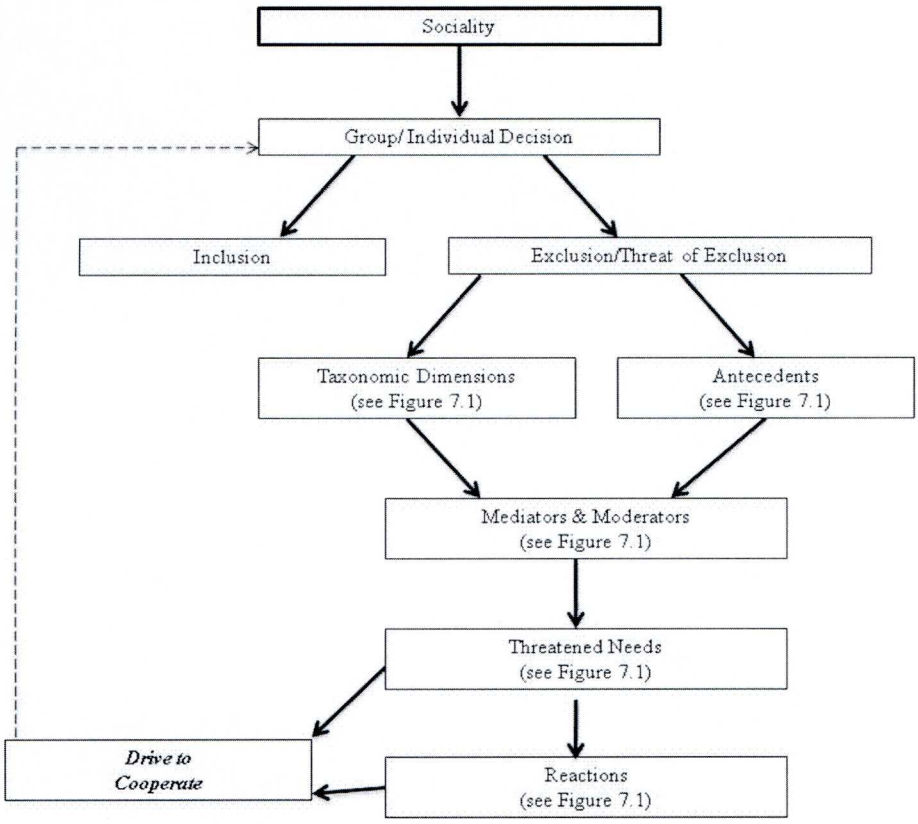


Figure 7.2. A hypothesized revision to Williams' (1997/2007) model of social exclusion. Note, I have included a box for *Drive to Cooperate*. I hypothesize that an individual who after feeling the effects of, or threat of, social exclusion tries to cooperate, the group is forced with making a decision about that individual's reinclusion. The drive to cooperate might be considered a short-term reaction under William's model.

meaningful existence was impacted by social exclusion in any of my studies. This effect could be the result of using the Cyberball game and because the social interaction is so removed participants do not feel that exclusion has any impact on meaningful existence. Furthermore, continuing to combine the study of social exclusion and cooperation may reveal a more holistic view of social interaction.

Further investigation of the effects of exclusion on group membership could be fertile for our understanding of how groups and individuals utilize

exclusion to maintain, dissolve, and setup social groups. Many of my findings suggest that exclusion and cooperation have been shaped by human evolution and that the human brain and biology is specifically adapted to cope with the social requirements of human survival. Continuing to look at social exclusion and cooperation through evolutionary lenses helps to highlight why individuals have such a strong drive to cooperate and why responses to exclusion can be so dramatic.

APPENDIX 1

Appendix 1.1. Social Exclusion Measure/Fundamental Needs Questionnaire (Williams et al., 2002; Zadro et al., 2004)

All questions are answered on a scale of 1 to 9:

1 = Not at all to **9 = Always**

1. In the last round, what percent of the throws were thrown to you?

1=0%
2= 25%
3=50%
4=75%
5=100%

2. To what extent were you included by the participants during the last game?

3. Overall in the last round did you feel accepted by the other players?

4. Overall in the last round did you feel rejected by the other players?

5. I felt poorly accepted by the other participants.

6. I felt as though I had made a connection or bonded with one or more of the participants during the Cyberball game.

7. I felt like an outsider during the Cyberball game.

8. I felt like I was able to throw the ball as often as I wanted during the game.

9. I felt somewhat frustrated during the game.

10. I felt in control during the Cyberball game.

11. During the game I felt good about myself.

12. I felt that the other participants failed to perceive me as a worthy and likeable person.

13. I felt somewhat inadequate during the Cyberball game.

14. I felt that my performance (e.g., catching the ball, deciding whom to throw the ball to) had some effect on the direction of the game.

15. I felt non-existent during the Cyberball game.

16. I felt as though my existence was meaningless during the Cyberball game.

17. Please select an adjective from each group that best describes your mood after playing Cyberball.

Bad, Good, Happy, Sad, Tense, Relaxed, Aroused, Not aroused

18. I felt angry during the Cyberball game.

19. I enjoyed playing the Cyberball game.

20. I believed that I was playing the Cyberball game with other people?
_____Yes
_____ No

Appendix 1.2. Rejection Sensitivity Questionnaire (Downey Berenson, and Kang, 2006; Downey and Feldman, 1996).

The items below describe situations in which people sometimes ask things of others. For each item, image that you are in the situation, and then answer the questions that follow it.

Each question is rated on a scale from 1 to 6:
Very unconcerned = 1 to Very concerned = 6 or
Very unlikely = 1 to Very likely = 6

1. You ask your parents or another family member for a loan to help you through a difficult financial time.

How concerned or anxious would you be over whether or not your family would want to help you?

I would expect that they would agree to help as much as they can.

2. You approach a close friend to talk after doing or saying something that seriously upset him/her.

How concerned or anxious would you be over whether or not your friend would want to talk with you?

I would expect that he/she would want to talk with me to try and work things out.

3. You bring up an issue of sexual protection with your significant other and tell him/her how important you think it is.

How concerned/anxious would you be over his/her reaction?

I would expect that he/she would be willing to discuss our possible options without getting defensive.

4. You ask your supervisor for help with a problem you have been having at work.

How concerned or anxious would you be over whether or not the person would want to help you?

I would expect that he/she would want to try to help me out.

5. After a bitter argument, you call or approach your significant other because you want to make up.

How concerned or anxious would you be over whether or not your significant other would want to make up with you.

I would expect that he or she would be as eager to make up, as I would be.

6. You ask your parents or other family members to come to an occasion important to you.

How concerned or anxious would you be over whether or not they would want to come?

I would expect that they would want to come.

7. At a party, you notice someone on the other side of the room that you'd like to get to know, and you approach him or her to try and start a conversation.

How concerned or anxious would you be over whether or not the person would want to talk with you?

I would expect that he/she would want to talk with me.

8. Lately, you've been noticing some distance between yourself and your significant other, and you ask him/her if there is something wrong.

How concerned or anxious would you be over whether or not he/she still loves you and wants to be with you?

I would expect that he/she will show sincere love and commitment to our relationship no matter what else may be going on.

9. You call a friend when there is something on your mind that you feel you really need to talk about.

How concerned or anxious would you be over whether or not your friend would listen?

I would expect that he/she would listen and support me.

Appendix 1.3. Empathy Quotient

Empathy Quotient-Short (A. Wakabayashi et al., 2006)

1. I can easily tell if someone else wants to enter a conversation.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

2. I really enjoy caring for other people.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

3. I find it hard to know what to do in a social situation.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

4. I often find it difficult to judge if something is rude or polite.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

5. In a conversation, I tend to focus on my own thoughts rather than on what my listener might be thinking

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

6. I can pick up quickly if someone says something and means another.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

7. It is hard for me to say why some things upset people so much.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

8. I find it easy to put myself in somebody else's shoes.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

9. I am good at predicting how someone will feel.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

10. I am quick to spot when someone in a group is feeling awkward or uncomfortable.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

11. I can't always see why someone should have felt offended by a remark.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

12. I don't tend to find social situations confusing.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

13. Other people tell me I am good at understanding how they are feeling and what they are thinking.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

14. I can easily tell if someone is interested or bored with what I am saying.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

15. Friends usually talk to me about their problems as they say that I am very understanding.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

16. I can sense if I am intruding, even if another person doesn't tell me.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

17. Other people often say that I am insensitive, though I don't always see why.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

18. I can tune into how someone else feels rapidly and intuitively.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

19. I can easily work out what another person might want to talk about.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

20. I can tell if someone is masking his or her true emotion.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

21. I am good at predicting what someone will do.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

22. I tend to get emotionally involved with a friend's problems.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

Appendix 1.4. Systemizing Quotient

Systemizing Quotient- Short (Wakabayashi et al., 2006)

1. If I were buying a car, I would want to obtain specific information about its engine capacity.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

2. If there was a problem with the electrical wiring in my home, I'd be able to fix it myself.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

3. I rarely read articles or web pages about new technology.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

4. I do not enjoy games that involve a high degree of strategy.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

5. I am fascinated by how machines work.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

6. In math, I am intrigued by the rules and patterns governing numbers.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

7. I find it difficult to understand instruction manuals for putting appliances together.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

8. If I were buying a computer I would want to know exact details about its hard disc drive capacity and processor speed.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

9. I find it difficult to read and understand maps.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

10. When I look at a piece of furniture, I do not notice the details of how it was constructed.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

11. I find it difficult to learn my way around a new city.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

12. I do not tend to watch science documentaries on television or read articles about science and nature.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

13. If I were buying a stereo, I would want to know about its precise technical features.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

14. I find it easy to grasp exactly how odds work in betting.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

15. I am not very meticulous when I carry out do it yourself projects

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

16. When I look at a building, I am curious about the precise way it was constructed.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

17. I find it difficult to understand information the bank sends me on different investment and saving systems.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

18. When travelling by train, I often wonder exactly how the rail networks are coordinated.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

19. If I were buying a camera, I would not look carefully into the quality of the lens.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

20. When I hear the weather forecast, I am not very interested in meteorological patterns.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

21. When I look at a mountain, I think about how precisely it was formed.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

22. I can easily visualize how the motorways in my region link up.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

23. When I'm in a plane, I do not think about the aerodynamics.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

24. I am interested in knowing the path a river takes from its source to the sea.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

25. I am not interested in understanding how wireless communication works.

A. STRONGLY AGREE

B. SLIGHTLY AGREE

C. SLIGHTLY DISAGREE

D. STRONGLY DISAGREE

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